FORESTRY

THE JOURNAL OF THE SOCIETY OF FORESTERS OF GREAT BRITAIN

Edited by R. W. V. PALMER

VOLUME XXVIII: NUMBER 2

Price
Fifteen Shillings

Published by the
OXFORD UNIVERSITY PRESS
LONDON: GEOFFREY CUMBERLEGE
AMEN HOUSE, E.C. 4
1955

COMMONWEALTH MYCOLOGICAL INSTITUTE
13 APR 1956

SOCIETY OF FORESTERS OF GREAT BRITAIN

THIS SOCIETY was formed at Aberdeen in 1925 and adopted its first Constitution at Oxford in 1926. This has been modified several times and the present Constitution became operative in December 1947.

The object of the Society is to advance and spread in Great Britain the knowledge of technical forestry in all its aspects. It is intended that the Society should be representative of the profession. Those not engaged in the practice of forestry or the allied sciences are cordially invited to join as Ordinary Members.

The activities include the publication of the journal, the holding of meetings, conferences, and excursions, and the awarding of a medal.

THE SOCIETY'S JOURNAL, called *Forestry*, is usually published twice a year, in January and July. It provides a means for the publication of the results of practice and research both in the growing of timber and in its utilization, including such basic sciences as forest physiology and ecology, forest soils, wood structure, and timber physics, and allied sciences such as forest entomology and forest mycology.

CONTRIBUTIONS may be accepted from members and others resident either in Great Britain or abroad. They should be sent to R. W. V. Palmer, Bannerleigh, Leigh Woods, Bristol. No article should be submitted which is being offered to any other journal for prior or simultaneous publication. Plates, figures, and tables should be used sparingly and their proportions designed to suit page dimensions, preferably, but not necessarily, for upright reading. Figures should be drawn large in black ink, preferably on Bristol board, and so as to allow appreciable reduction to page width without loss of clarity in the smaller details. Marginal lettering is best inserted in pencil. If graph coordinates are to be reproduced, graph paper with blue lines must be avoided. References to literature should be collected at the end of the paper, and arranged alphabetically according to author's name, and numbered. In the text each reference should be indicated by its number enclosed in brackets. Each article should begin with a summary which should be factual and convey briefly the content of the article and draw attention to all new information and to the main conclusions. It should be concise and should not normally exceed 200 words. It is understood that the author waives any copyright or translation rights in such summaries and that their reproduction in other publications will be permitted, subject to the source being duly acknowledged. Twenty reprints of the article will be sent free to each contributor and a reasonable number may be purchased by the contributor if ordered when the proofs are returned. The Society as a body takes no responsibility for the views expressed by contributors.

Forestry is sent free to members of the Society; others may register as subscribers by application to the Secretary, The Society of Foresters of Great Britain, 7 Albyn Place, Edinburgh, 2.

SOCIETY'S MEDAL. This may be awarded by the Society to any individual who has rendered eminent services to British forestry. Proposals for the award have to be made in the first instance to the Council by a Member of the Council. The regulations for the award will be found in Vol. XX, pp. 80, 81, and in Rule 11.

[continued on inside back cover

FIG. 1. View of typical torrent bed and eroded hillsides in the background, terraced for planting in middle distance. From Conchigilia looking north-west. Camaro State Forest, Peloritani Mts., N.E. Sicily. (Photo.: M. V. Laurie, 2.10.53.)

FIG. 2. Plantation of *Pinus halepensis* with some *Pinus pinea* on terraced limestone hillside, showing the enormous amount of work necessary to conserve the little remaining soil on these eroded mountains. The two forms of *Cupressus sempervirens*, erect and spreading, are seen in the foreground. Unreclaimed hillsides in background. San Martino alla Scale, near Palermo, Sicily. (Photo.: M. V. Laurie, 28.9.53.)

PLATE IV

NOTES ON FORESTRY IN SICILY

By JAMES MACDONALD

SUMMARY

An account, by a delegate from Great Britain to the eleventh Congress of the International Union of Forest Research Organizations held in Rome in 1953, of some aspects of the work being undertaken by the Government of Sicily to restore fertility to degraded soils and thereby prosperity to the island by the control of torrents and by afforestation in the torrid climate of the mountains of southern Europe.

THE eleventh Congress of the International Union of Forest Research Organizations, which was held in Rome towards the end of September 1953, was followed by a study tour in Sicily. About a hundred delegates visited that famous island and took part in a most interesting and valuable tour, ably organized by Professor Pavari, the new President of the Union, and Professor de Philippis and their colleagues, and made memorable by the hospitality of the Regional Government of Sicily. Our stay in Sicily lasted a week, the first few days being spent in the capital city of Palermo; during the remainder of the time our centre was the celebrated town of Taormina, perched on a cliff, high above the Ionian Sea.

One may ask what there is in Sicily to interest professionally a forester from north-western Europe where things are so different. Actually, there is more than one might think. When travelling to Rome, I was greatly impressed by the silhouette, against the Mediterranean sky, of the island of Elba, which reminded me very much of one prospect of the island of Skye. And when we landed in Sicily I found that the problems facing foresters there had a certain basic similarity to those which confront foresters in the west and north of Scotland. In both countries the natural forest growth has disappeared or almost completely disappeared, the victim of fire and of the grazing tooth of flocks and herds; in both these are grave sociological problems, though different in character; in both the improvement of degraded sites is one of the principal tasks of the forester. There, however, the similarity ends. There are enormous differences in soil, in climate, and in tradition.

The island of Sicily extends to about 10,000 square miles; rather bigger than Wales, but it is the largest European island after Great Britain and Ireland. It is hilly and even mountainous. Apart from the great volcanic cone of Etna (10,870 feet) which dominates the eastern part of the island, there are mountains rising to 6,000 feet in the Madonie which lie in the centre of Sicily, north-west of Enna and Caltanisetta, while there are numerous eminences, 3,000 and 4,000 feet high, in other parts of the island. In some places the mountains come right down to the coast, but there is generally a coastal plain between the hills and the sea, often quite narrow, but quite extensive at the western end of Sicily and along some parts of the southern coast. The rivers which run down from the highlands to the sea were all dry, but their wide torrent beds, with boulders, shingle, and sand, afforded ample evidence of the force with which they must run in the rainy season.

There were signs of erosion everywhere except on the recent lavas of Mount Etna and on some of the bare limestone hills where there was nothing much left to erode.

Much of the underlying rock is limestone, some of Jurassic age, some of Triassic, but in the north-east, behind Messina, there are gneisses and schists while in the east and south-east there are the great lava flows. In the centre of Sicily there are clays, sandstones, and conglomerates associated with deposits of salt and layers of bitumen, while chalk also occurs, and it is in the chalk region that the sulphur deposits are found. We are fortunate in Great Britain in having geological maps which can be purchased without difficulty. In Italy they are not to be had and the lack of them is a very serious handicap on a visit such as we made on this occasion.

Here, in the north, we occasionally think of the Mediterranean climate as something highly desirable for, under our cloudy skies, the thought of sunshine and warmth is not without its attraction. But, in reality, the Mediterranean climate has its brutal side, for the winters, which are mild and moist, are followed by a prolonged period in which temperatures are high and little rain falls. When we arrived in Sicily at the beginning of October the temperature was over 90° F. and even at that late date we obtained a good impression of the sufferings which the sun inflicts. The average winter temperature on the coast is about 53° F., on the higher ground inland 48° F.; in the summer the mean temperature is in the neighbourhood of 75° F. Catania gets 2,560 hours of sunshine a year, Messina 2,400, and Palermo 2,200, with 125, 110, and 98 completely cloudless days respectively. In Great Britain there is no place receiving as much as 1,700 hours per annum.

The rain falls almost entirely between the end of October and the beginning of April, leaving the rest of the year practically rainless; this has led to the development of vegetation which is strongly xerophilous in character. It is this feature of the climate, combined with the high summer temperatures which makes the establishment of young tree crops so difficult. On the other hand, the trees do not suffer from frost and there is a complete absence, even at high elevations, of the effects of exposure which, with us, are commonplace enough. Rainfall varies from under 20 inches a year on the south-west coast to 40 to 60 inches on Mount Etna. Snow falls in winter on the mountains above 5,000 feet but it does not lie except above 6,000 feet on Etna and, for a shorter time, on the high, northern slopes of the Madonie mountains.

Erosion is everywhere in evidence; the soils are unstable and when the rain falls heavily in winter serious damage is done. The risks of soil erosion have been gravely accentuated by the effects of grazing by domestic animals continued over centuries. The original forest cover has almost all gone and it is now being recreated with great effort and heavy expenditure.

The forest area of Sicily is only 3·4 per cent. of the total land area—a very low figure. It is made up as shown in the table opposite.

At the time of our visit the crops had been gathered and the fields were empty except for some small patches of maize, artichokes, beans, and red-peppers. This, in a way, was a pity, because one of the most interesting things about foreign travel is the chance it gives one to see how other people grow their crops, and

what kind of crops they grow. About a million and three-quarter acres are normally under corn, wheat, and barley mostly (Sicily was a great granary of ancient Rome), but the yield is low, 4–5 cwt. per acre. The grain-producing region lies in the centre of the island, where there are the great estates or *latifundia*. This region is thinly peopled; it is to a great extent, monocultural, only fodder crops for cattle and goats alternating with the corn; it is subject to erosion; it presents some awkward sociological problems.

High Forest	*acres*
Pure conifers	13,457
Mixed conifers	423
Pure broadleaved	27,841
Mixed broadleaved	16,926
Mixed conifer and broadleaved	6,543
Total High Forest	65,190
Coppice with Standards	
Pure	19,007
Mixed	32,447
Total Coppice with Standards	51,454
Simple Coppice	
Pure	88,916
Mixed	9,600
Total Coppice	98,516
Grand Total	215,160 acres

Round the coast conditions are different. Holdings of land are small; there is intense cultivation; there is a bewildering variety of crops. In the coastal districts which we visited, the outstanding feature was the plantations of olives, oranges, and lemons. The strange, grey foliage of the olive and the magnificent deep green of the lemons and oranges formed a contrast which was particularly satisfying to the eye. Numerous small vineyards and plantations of figs and almonds added to the variety of the scene, although the main centre for vine-growing is in the west around Marsala and Trapani and for almonds, in the south, round Agrigento. I usually keep some Marsala at home but at all the parties which we attended in Sicily I saw but one bottle of this famous wine. It bore Wodehouse's label.

In the fields they produce large quantities of vegetables, many of them cash crops to catch the early markets, such as tomatoes and artichokes; beans, peas, and more recent introductions like maize and tobacco are also grown, as well as limited quantities of cotton, one of the plants introduced long ago by the Arabs. Rice, another Arab introduction, is little grown and we saw none in Sicily, although there were some small patches visible in Italy itself, while a third plant brought in by the Arabs—sugar-cane—is no longer grown; they have some small areas of sugar beet now instead.

The annual production of olives in Sicily is 420,000 tons, 66,000 tons of olive oil; 296,000 tons of oranges, 268,000 of lemons, and 68,000 of mandarines are also produced, as well as 61,000 tons of almonds and 11,000 tons of hazel nuts. Grapes to the weight of 340,000 tons are cut for wine-making and 30,000 tons for consumption as fruit. Of the annual crops, tomatoes yield 240,000 tons annually, dried beans 165,000 tons, fresh broad beans 62,000 tons, and fresh peas 21,000 tons.

To the Arabs is due the introduction of two important devices which play a prominent part in Sicily—terracing for cultivation, and irrigation. On all the hillsides the terraced slopes with the soil retained by stone walls strike the eye at every turn, while the presence of irrigation channels, in orchards, plantations, and gardens, shows the widespread use of this essential practice. To irrigation is due no doubt much of the amazing growth which is found at various places round the island.

A forester from northern Europe, suddenly finding himself in Palermo, views with astonishment the fantastic jumble of trees which adorn the streets and gardens of that great and historic city. Avenues of palms, of planes, of various species of *Ficus*, and perhaps most attractive of all, of the South American pepper tree, *Schinus molle*, line the sunny streets. Outside our seaside hotel, a mile or two from Palermo, we saw, in close proximity, *Melia azedarach*, *Ficus elastica*, *Cercis siliquastrum*, *Eucalyptus rostrata*, *Acacia saligna*, various species of *Yucca*, of *Cycas*, and of *Phoenix* including the date palm, *Populus alba* possibly a variety, *Platanus acerifolia*, *Casuarina equisetifolia*, *Myoporum insular*, and *Chorisia speciosa* with striking flowers of purple—trees from all five continents, brought together and growing happily in the open air, aided in most places by irrigation.

In the Botanic garden of the University of Palermo, which we were privileged to visit, there were great shaggy specimens of the Canary Island pine, *P. canariensis*, a tree which I had never seen before, and of *Pinus brutia*, a Near Eastern tree which does very badly with us, and which it was interesting to see growing well. Australian araucarias and agathis were excellent, but conifers from the higher latitudes of the northern hemisphere were poor, the spruces in particular being most miserable in appearance. There was one large specimen of *Platanus orientalis* 70 feet high and 13 feet in girth at breast height and numerous substantial trees of various species of *Ficus*. Among other trees, there were good examples of *Grevillea*, *Pithecolobium brevifolium*, *Citrus triptera*, *apollonia canariensise*, *Brachychiton*, and *Tilia argentea*, while the profusion of sterculias was quite remarkable.

It was curious to find, in Sicily (and in Rome), men planting large stone pines (*Pinus pinea* L.), 8—10 feet high, in a shade temperature of over 90°. These trees are specially grown for street and garden planting and they are moved to the planting sites with balls of earth attached. But they get no special treatment beyond a thorough watering at the time of planting and for a few days afterwards, as well as having their foliage sprayed. In spite of this rather crude treatment and in spite of the great heat, the trees survive. It may be that we, in this country, are too nervous about such drastic treatments. One thing I am sorry I missed seeing at

Palermo was the manufacture of manna from the manna ash, *Fraxinus ornus*. This is an old-established industry but, of latter years, it has decayed and is now no longer of any great importance. The manufacture of manna is centred on Palermo and on Cefalu, farther east, along the northern coast.

Little of the original forest of Sicily now remains and silviculture with the Sicilians is pretty much what it is with us, a matter of afforestation and replanting. Most of the forest disappeared long ago but on the great mountain of Etna there is enough left to give some idea of the original distribution of forest types, a distribution stratified by altitude but modified by aspect. Among the botanists and plant geographers who have studied the vegetation of this region is the new President of the Union, Professor Aldo Pavari of Florence. His classification is given on page 86.

The *Lauretum* zone is now under intensive cultivation. Round the base of the volcano and on the lower slopes, the old lava flows, chiefly of basalt, have given rise to a fertile soil, rather acid in reaction which is now intensively cultivated, with terracing where that is needed. Our first approach to the mountain was from the north, from the small town of Linguaglossa through plantations of olives and other trees, through vegetable fields, orchards, and vineyards; we stopped a short way up the mountain beside a field of vines to hear an account of the forest vegetation of Etna and as we stood there by the roadside I could not help observing that the soil and the rock exposed by a cutting seemed almost identical with some of the profiles one can see in the volcanic districts of central Scotland. Somewhere above that point we passed into the *Castanetum* and there were numerous crops of hazel and chestnut, grown as a kind of coppice for their fruits. At about 2,600 feet we came into a belt of oak, interrupted by more recent lava flows, almost devoid of vegetation; the species was *Quercus lanuginosa* mostly coppiced and apparently little worked except for firewood. There is small use in the cultivated districts for products such as our coppice-grown pea-sticks and bean-rods. For those purposes the Italians use the canes of the large grass *Saccharum aegypticum*, which is found everywhere in odd corners, growing to about 10 feet in height. This oak coppice, which is worked on a rotation of 15 years, is said to have an annual increment of about 38 cubic feet per acre.

Somewhere about 3,000 feet the first of the pine began to appear, forming a zone of mixed forest with the oak and we soon passed into pure pine forest. The pine, *Pinus nigra* var. *calabrica*, was examined in the Forest of Ragabo, a forest about 4,000 feet up the mountain on the northern slope, which has only relatively recently been opened up and made accessible by the construction of roads. It extends to about 4,500 acres. The pine, which appeared to be similar to the Corsican pine save that the needles were rather stiffer, were trees of good form and with fine, clean boles. Much of the forest is pure; at the lower limits the pine and oak occur in mixture; towards the upper limits beech becomes more prominent. Birch, *Betula verrucosa* var. *aetnensis*, is also found in mixture with the pine. There are no exact records of rainfall in this forest, but it is more than 40 inches annually, while snow is frequent in winter, lying up to 2½ feet in depth.

A summary of zonation of vegetation on Mount Etna (Pavari's classification)

Zone	*Mean annual temp.*	*Mean temp. of coldest month*	*Mean absolute minima*	*Altitude range (metres)*	*Principal components of vegetation*
1. LAURETUM (*a*) *Warm sub-zone* (e.g. Acireals 177 m.)	15–23° C.	7° C.	−4° C.	450–600 m.	Cultivated oranges, figs, and prickly pear. Natural vegetation: *Ceratonia siliqua*, *Olea oleaster*, *Rosmarinus officinalis*, *Euphorbia dendroides*, *Ferula communis*, *Rhus coriaria*
(*b*) *Temperate sub-zone* (e.g. Linguaglossa, 560 m.)	14–18° C.	5° C.	−7 C.	..	*Celtis australis*, *C. tournefortii* var. *aetnensis*, *Rhus cotinus*, *Rhus pentaphylla*, *Platanus orientalis*, *Pistacia terebinthus*
(*c*) *Cold sub-zone* (e.g. Castiglione 620 m.)	12–17° C.	3° C.	−9° C.	Upper limits—south exposure 900 m.; other exposures 700–800 m.	*Spartium junceum*, *Phyllinea variabilis*, *Cytisus triflorus*, *Quercus ilex*, *Pinus pinea*, *Pinus halepensis*, *Juniperus oxycedrus*
2. CASTANETUM (e.g. Capriolo, 1,440 m.)	10–15° C.	0° C.	−12° C.	700–900 m. to 1,500–1,600 m.	Rich in forest species, *Castanea sativa* (4,000 ha.), *Quercus lanuginosa*, *Quercus cerris*, *Corylus avellana* (1,400 ha.), *Genista aetnensis*, *Carpinus betulus*
3. FAGETUM (*a*) *Warm sub-zone*	7–12° C.	−2° C.	−20° C.	1,500–1,650 m. to 1,900 m.	*Fagus sylvatica*, *Pinus nigra* var. *calabrica* (2,500 ha.), *Quercus cerris*
(*b*) *Cold sub-zone*	6–12° C.	−4° C.	−25° C.	1,900–2,100 m.	*Betula alba* var. *aetnensis*, *Populus tremula*, *Fagus sylvatica* (*Taxus baccata* on north slopes, and *Carpinus betulus*, *Tilia cordata* on south slopes)
4. ALPINETUM	..	..	..	Limit of true forest lies in higher *Fagetum*. Above 2,100 m. mainly shrubs such as *Juniperus hemisphaerica* and *Astralagus siculus*, up to 2,900 m. Above this height shrubs give way to species such as *Rumex scretatus*, *Senecion aetnensis*, *Scleranthus annuus* var. *aetnensis*. Above 2,970 m. the land is entirely barren	

FIG. 3. Pure natural crop of *Pinus nigra* var. *calabrica* at 4,500 feet on north side of Mount Etna. Crop height about 85 feet. Average age of older classes about 80 years. Pineta Ragabo, on northern slopes of Mount Etna, Sicily. (Photo: M. V. Laurie, 3.10.53.)

PLATE V

Because of the lack of access, only recently remedied, there has been no systematic management in the Forest of Ragabo, but this will now be put right and an effective system of management introduced. To do so will take some time, for the age-classes are far from normal, with a preponderance of the 40–80-year age-class. Where conditions of light are suitable, natural regeneration occurs freely, and it is proposed to conduct operations on the shelterwood system, in which about 50 trees per acre will be left for seeding. Although the elevation is considerable, exposure is not severe and there seems to be a freedom from storm damage and from exposure effects which surprises a visitor from the Atlantic seaboard of north-western Europe who would not expect a shelterwood system to function very long in a similar situation in his own country. Lack of thinning in the past has led to a stock of trees on the ground which was said to be dense—400 to 600 trees per acre at 50 years of age—but I must confess that the trees did not appear to me to be standing excessively close together. Some concern was expressed at the increasing acidity of the superficial layers of the soil resulting from the accumulation of undecayed needles where the canopy was denser, but it seemed that the climate, even in this high-lying forest, would soon lead to their decomposition if the crop were only slightly opened. The stock standing in different parts of the forest varies considerably as volumes range from 1,100 to 4,000 cubic feet per acre, while the increment also has a wide range, from 12 to 70 cubic feet per acre per annum.

So far as I am aware, there is no plantation anywhere in Great Britain raised from seed collected on Mount Etna, and thus in speculating about the possible value of this pine for planting here one has nothing on which to base a judgement. The probability is that it is unlikely to be better than the Corsican stock, for that, used in its proper place, is so good that there seems little chance that the Mount Etna form will better it. We are, however, obtaining seed from Sicily for trial.

From Ragabo we descended the mountain by the way we came and then travelled along its eastern flank by Fornaggo and Zafferana to Nicolosi on its southern rim, whence we climbed, on a first-class motor road, to the Grand Hotel Etna at just over 6,000 feet. On the eastern side we saw a recent lava stream which came down in 1951, destroying a belt of forest and cutting the main road. This was in itself an impressive sight, but it was not until we had started to climb to the hotel that the sombre volcanic landscape, with its piled lavas, bare and dirty-brown in colour, struck us with full force and made us realize the consequences of the great eruptions which have issued from Etna at intervals over the centuries. In course of time the lavas give rise to useful soils, but soil formation is an exceedingly slow process; the lavas vary to some extent, and on the more difficult streams plant life may take centuries to develop, as we were able to see in the lava from the eruption of the year 1660, which is still almost completely bare and lacking in vegetation. Lichens and mosses are the pioneers in the colonization of the lavas and these are followed by the large shrub, *Genista aetnensis*, which has the unique ability to establish itself on those sites where weathering of the lava is still in its early stages. It can reach a height of about 20 feet.

The sole example of forestry which we were able to see, brightening the melancholy aspect of the southern slope of Etna, was the successful afforestation on the Monti Rossi of cones thrown up in the great eruption of 1669. Several areas here have been stocked with stone pine (*Pinus pinea*), which was established by direct sowing on terraces specially cut in the slopes.

The rest of the visit was devoted to a study of some of the extensive works of reforestation and afforestation which are being conducted with vigour in many parts of Sicily. Most of these are in hilly or mountainous country but we were able to see one attempt at planting on the beach at Mascali, about a dozen miles south of Taormina. The object of this work is twofold, to establish a protective windbelt along the shore and, secondly, to improve the appearance of the bare beaches. The mixture of plants was a new one to me as the plantation was composed of six rows of *Eucalyptus rostrata* and *Casuarina equisetifolia* mixed, followed by one row of *Acacia cyanophylla*. The trees had just completed their second year's growth; the *Acacia* seemed quite at home and were from 6 to 8 feet high; the *Eucalyptus*, though not apparently so vigorous, were almost as tall, but the *Casuarina* were irregular in growth and not very healthy in colour. The site is possibly too dry for this tree. The land was prepared for planting by digging trenches 1 metre deep at intervals of $2\frac{1}{2}$ metres and in these trenches the trees were planted $2\frac{1}{2}$ metres apart in the autumn and well watered immediately after. This seems an elaborate form of preparation for a plantation of this kind, and must have been costly, but, here, as elsewhere in Sicily, we found ourselves faced with a different scale of values. There is no point in mechanization which aims at replacing men by machines when the problem is how to use large numbers of men who have little else to do.

Bare limestone hills, with light-coloured rock everywhere protruding and with a thin straggling vegetation mostly xerophytic in character, are a feature of the country around Palermo, as indeed they are in other parts of the Mediterranean region. They do not look favourable for forest operations but there they are, a challenge to the forester to try to repair the damage caused by centuries of misuse. That challenge has been taken up with vigour in Sicily and we were able to examine two areas in which afforestation is proceeding, one at San Martino alle Scala, a few miles inland from Palermo and the other on Monte Pellegrino, the headland which rises above the harbour of the town.

Round about San Martino the limestone hills run up to nearly 3,000 feet and they have been eroded into a complicated system of valleys. Erosion is still proceeding, for much of the 20 inches of rainfall, which comes down almost entirely in the winter, descends in sudden storms which can cause extensive loss of soil. Although the climax vegetation of this locality would probably fall into the temperate subzone of Pavari's 'Lauretum', grazing by goats continued for a very long time has removed almost all the woody growth, and the vegetation now consists of a thin covering of tough grasses—fescues mainly, low, shrubby, and herbaceous plants, many of them aromatic, including *Erica multiflora*, *Cistus*, *Teucrium*, *Eryngium*, *Euphorbia*, *Calendula*, *Smilax*, *Thymus*, *Psorallea bituminosa*, and various others, bulbous plants like *Iris*, *Narcissus*, and the Neapolitan *Cyclamen*, a few blooms of

which were the only wild flowers I saw. The soil, on the higher ground, is calcareous and sandy, and there are frequent outcrops of rock; on the lower slopes it is a marly clay.

The State Forest, which is being created round the basin of the torrent Passo di Rignano, will eventually extend to about 6,000 acres, but up to the present time only about 1,400 acres have been planted. The earliest attempts at tree planting in this forest are now about 30 years old, but these plantations suffered severely during the war when they were plundered for fuel wood, which was then very scarce; they were also damaged badly by goats. The work which has been going on since the war has been directed towards extending the planted area and to the repair of the older plantations. The difficulties facing the planter on a site like this originate in the climate and in the soil. The climate, with 4 to 5 months' drought during the long rainless summer and with high temperatures, makes the conservation of moisture essential if newly planted stock are to survive; the soil, which is shallow on the steeper slopes, must be kept in position and saved from erosion by the winter rains. The soil is also highly calcareous, which limits the choice of species for planting.

Protection of the soil and conservation of moisture are effected by terracing. Rough stone walls are erected along the contours at close intervals and on the upper side of each the soil is levelled into a terrace about 2 feet wide, on which planting is done.

As for species, the lime-loving Aleppo pine (*P. halepensis*) has been widely planted and has succeeded well. The stone pine (*P. pinea*) is also good and we saw something of its possibilities lower down the mountain in a stand of fine trees with characteristic rounded crowns. It is important for its timber and as a source of food. The seeds, the 'pine kernels' of our shops, are an important commodity, much in demand. I was informed that the yield of seed is about 1¾ cwt. per acre. Among other trees which are succeeding are the Mediterranean cypress (*C. sempervirens*) which seems to vary in habit, some trees being much narrower and spire-like than others (see Fig. 2). Another cypress, the familiar C. *macrocarpa* had also been tried in a small way and was looking remarkably well. The effect of the calcareous soil is seen best of all in a series of plots of *Pinus pinaster* of different origins in which different races or strains of this tree can be compared. *Pinaster* from the Landes of France was showing pronounced lime-induced chlorosis of the foliage and was lacking in vigour; the same symptoms, though not so strongly marked, were exhibited by the local Sicilian race. The best was a lot from central Italy, which appeared to be normal. Growth of all species is slow, by our standards, as the best of the pines were from 10 to 15 feet in height at 18 years of age.

On Monte Pellegrino we saw how the same problems, in an acuter form, were being dealt with. This headland rises out of the sea to a height of about 2,000 feet; much of the mountain is unplantable because of steep limestone faces without soil but the more moderate slopes, which carry a variable depth of rather brashy soil, can be terraced, and it is on sites like this that work is proceeding. Vegetation is not abundant and consists of the usual xerophilous species and tough wiry grasses. When work on Monte Pellegrino started, the practice which was followed

consisted of direct sowing on cultivated patches. Although this led to some success, the method as a whole was unreliable. There was often poor germination, while heavy losses occurred among germinated seedlings during the summer. The methods now used, based on much valuable experimental work by Professor de Philippis of Florence, involve a very shallow form of cultivation and the use of terraces wherever these can be built. In this area they use about 1,200 yards of terrace per acre, constructed at a cost of between £50 and £80. This is a heavy initial outlay, enough to make an economist blench, but here we are faced, as we are faced in war, with a set of circumstances in which orthodox economics do not function.

On the terraces a narrow groove is prepared about 1 inch deep and 1½ inches wide and in this groove the seeds are sown about 2 inches apart. The seeds are treated with a repellent substance before sowing to keep rodents away and also, it was said, to render them unpalatable to human beings. Sowing is usually done in August or September; this allows the seed to germinate with the first rains of autumn and permits the seedlings to develop a good root system before they are called on to face the drought of the following summer. If there are gaps to be filled the year after, they are filled with 1+1 transplants brought up to the site in pots and planted with the ball of soil from the pot. Experience has shown that planting with bare roots is rarely successful.

The principal species which have been raised in this way are the Aleppo pine, the stone pine, and the Mediterranean cypress. There was, however, an interesting trial of *Cupressus lusitanica* which shows some promise. On the steeper slopes, where terracing is impossible, eucalypts, especially *E. rostrata* and *E. gompho-cephalus*, are being planted. They are put out directly from pots which are brought up to the planting site.

The district forest nursery near Palermo was of great interest both for the methods used and for the species which are grown. The régime is really quite simple, although, to northern eyes, there was an unfamiliar and exotic look about the establishment. Seedlings are raised in drill-sown seed-beds and at the end of 1 year transplanted into pots in which they remain for 1 year more. The standard planting stock is thus a pot-grown 1+1 transplant. It is necessary to water during the summer; this is done by the usual overhead spray; without it one judges that the results would be very poor. Those in charge of the nursery are chary about manuring; they consider that fertilizers should be applied only at the minimum rates because what they have to avoid is the production of large, lush plants which would fare badly in the harsh conditions to which they are exposed after planting. The pots in which the transplants are grown are the common clay pots familiar to us all; the Silician foresters are experimenting with pots of compressed paper, which are lighter and may be cheaper.

The other example of mountain afforestation which we saw was on the Monte Peloritani, a series of high ridges behind Messina, at the north-eastern corner of Sicily. Here there is the same eroded landscape but the limestone is absent. Instead, the metamorphosed rocks, gneisses, and crystalline and mica schists which occur give rise to soils of a more acid character on which plants like *Erica arborea* and

Pteridium aquilinum are often abundant. The forest area, round the headquarters of the State Forest Administration at Colle San Rizzo, will eventually extend to about 15,000 acres; at present it covers about 5,500 acres. Much of the planting has been done with *Pinus pinea*, which is at home here and is grown not only for its timber but for its seed; to encourage seed production the trees are allowed to form bushy crowns and are usually pruned up to about 10 feet. *Pinus radiata* has also been used and, although the interesting experimental plots of this species were destroyed by a fire during the war, another plantation which we were able to visit gave us some idea of the early growth of *radiata* in Sicily. At 13 years of age the crop was about 28 feet high, with a mean quarter girth of $5\frac{1}{2}$ inches; there were 650 stems per acre, a volume standing of 1,570 cubic feet per acre, and a mean annual increment of 120 cubic feet. Increment like this is regarded as highly satisfactory, as the stone pine on the same kind of site would yield only about 40 cubic feet per acre per annum. There is said to be little difficulty about the establishment of *Pinus radiata* and this, together with its useful volume production, makes the Sicilian foresters think that it will be a useful species to grow for pulp wood on a short rotation. In this forest, also, there is a plot of *Pinus longifolia* (*P. roxburghii* Sarg.) worth mentioning, although it was too far away for us to see, because it is reputed to be the only plantation of this species in Europe. Twenty years old, it has a mean height of 28 feet and a mean quarter girth of 6 inches. There are only 280 trees per acre because of damage during the war and this thin stocking is responsible for the low volume of 675 cubic feet and the low mean annual increment of 34 cubic feet per acre. It was pointed out that anything like a normal stock would give an increment of about 70 cubic feet per acre annually. In this forest there has been much experimental planting of eucalypts and a large number of different species was seen, mostly in small groups. These date from 1927. The most vigorous appeared to be *E. rostrata* and *E. maideni* but there were good specimens of other species including *E. blaxlandi*, one tree of which had a quarter girth of 15 inches at breast height. From 1930 onwards there has been an increasing use of acacia in this forest, with an eye on its value as a source of tannins. In contrast to the eucalypts, which are planted, the acacias are raised by direct sowing and they are used in mixture with pines to reduce the fire risk. *A. pycnantha* is considered of special value in this connexion. Among other species used are *A. saligna* and *A. melanoxylon*. The tannin content of the bark of the acacias in Sicily is about 14 per cent.

We spent one long, but most interesting day in the Piazza Armerina, to the south-east of the famous hill-town of Enna, in the centre of the island. Although this is also a high-lying area, it is different from those others which we visited, because the land is not rocky and with thin soils, but characterized by deep sandy and clay soils derived from the Pliocene long cultivated and subject to most severe erosion which steadily becomes worse, threatening even the railways and the roads.

Accordingly the Regional Government of Sicily decided to pursue a large scheme of afforestation, using the slopes and the most severely eroded ground, and aiming at the planting of about 30,000 acres. Finance was provided out of the 'Cassa del Mezzogiorno', a fund created by the Government of Italy in 1950 to

finance improvement schemes in the depressed districts of southern Italy, and the co-operation was enlisted of the Snia-Viscosa Industrial Group which is interested in the supply of raw material for cellulose. Members of this group, the SIACE company and the IRMO company, have started extensive works of afforestation and this activity has been reinforced by planting schemes put into operation by the State service in the same district. Eucalypts are the main species and the object, at present, is to grow them eventually on short rotations as coppice.

The raising of planting stock in the nursery was seen at a large State nursery and at a smaller nursery managed by the SIACE company. The methods were the same as those which we had already seen at Palermo, and again we were impressed by the enormous amount of work involved in raising several million plants, each in its own pot, especially when each pot has to be lifted periodically so that roots which have come through may be pruned off. The species grown were mainly eucalypts: *E. globulus* and *E. rostrata* were the most important but *E. botryoides* and some others also occurred.

We saw some of the recent planting and in several places the newly planted areas were extremely similar to some of our own, for the planting was carried out in trenches, dug by hand, along the contours, giving an effect almost exactly the same as ploughing carried out with one of our heavier ploughs. Towards the end of the day, near Pelagonia, we inspected, at close quarters, the work which was proceeding to reclaim a steep and severely eroded clay slope. It had been necessary to build check dams of masonry across the worst of the gullies, while the steep slopes were being broken up into steps for planting by means of explosives. The slope on which I walked with some hesitation seemed to be extremely precarious and liable to slip at any moment; it had been planted with *Eucalyptus* and with the prickly pear *Opuntia*, which is greatly used when rapid soil fixation is required.

The possibilities of the district for tree growth were demonstrated by some older plantations formed between 1930 and 1940 by the *Milizia Forestale*. We walked through one very nice plantation in which *E. rostrata* and *E. globulus* were both present, the latter standing out by reason of its habit of early bark shedding. There were also occasional specimens of *Cupressus sempervirens*, *Celtis australis*, and the walnut. *E. globulus* in 20 years had reached a height of 77 feet with a breast height quarter girth of 11½ inches; in the same time, *E. rostrata* was 69 feet high and 9½ inches at breast height. *Globulus* is the faster grower and it has been estimated that it would produce almost double the volume put on by *rostrata*. Nevertheless *rostrata* is the better tree for pulp. Grown as coppice, *globulus* in 11 years reached a height of 36 feet with a quarter girth of 7½ inches; *rostrata*, on the other hand, in 10 years was only 26 feet high with a girth of no more than 4½ inches.

The research work which is being carried out at the Pulp and Paper Research Station of Sicily impressed all the visitors when they visited this Institute near Palermo. Dr. Palazzo, the Director, who proved to be a most stimulating guide, told us that their objects were to investigate the numerous materials grown in Sicily and to estimate their value as possible sources of pulp and cellulose. Italy is almost entirely dependent for her raw material in this field on outside sources of

supply and efforts are being made to increase the production from Italian soil. The wide range of plant materials which was being examined was evidence of the broad sweep of the investigations; they included not only products of the forest, but agricultural wastes of all kinds.

The Sicilian plantations, apart from the unfamiliar species of which they are composed, differ from ours because they are so much more irregular; it was only in the most favourable sites that we found growth and stocking of the regularity shown by our plantations. That is not necessarily a bad thing but it caught my eye at once because I have for so long been used to the other. There is an element of incongruity about some of the mixtures when pines, eucalypts, and acacias are assembled together and it is difficult to forecast their ultimate pattern of development and the form which regeneration will take when its time arrives. Heavy crops cannot be expected on most of the sites which we visited and it seemed to me that in the harder, hotter localities one could expect only a relatively low stock of timber on the ground.

The visitors noted in particular the close links between afforestation and utilization and were greatly impressed by the work which is being carried out on materials for cellulose and pulp production in the research station at Palermo where, among other things, the staff are investigating small timber and sawmill waste. The participation in the schemes of afforestation of a great commercial enterprise is also noteworthy and it was interesting to observe how well this concern worked with the Forest Service.

Protection of the new forests must always remain a serious burden for those in whose charge they are. They are now effectively protected against grazing animals and, if this protection is maintained, there will undoubtedly be a great improvement in conditions, perhaps more rapid than one might imagine. Fire is also a grave hazard; the climate and the inflammable nature of many of the crops create a very serious risk. Of this the authorities are highly conscious and their precautions are obviously effective, for we saw no sign of recent damage by fire in any of the forests which we visited. And yet nowhere did we see the evidence of a fire-fighting organization which is so familiar in our forests. Although in Great Britain we do not have the same intense risk of fire or over so long a period, we do have a hazard, which in Sicily is not so pronounced, in the heavy bulk of herbage which develops in our climate. On the Sicilian hills the vegetation is thin and interrupted by patches of rock and bare soil which must have the effect of slowing down or breaking up a fire approaching the forest from outside.

In their schemes of afforestation the Government of Sicily have promoted an undertaking which will have far-reaching consequences in the restoration of fertility to the hills, in the control of torrents and of erosion, in the provision of employment and in the production of much-needed raw material, and all foresters hope that their enlightened policy will meet with full success. The Forest Service, on whom has fallen the duty of putting the policy into operation, have undertaken a task which might daunt all but the stoutest hearted. In face of the most formidable difficulties, they have made a most auspicious start and all who have seen their work will wish them well in their great task.

FOURTH WORLD FORESTRY CONGRESS, 1954

THE Congress assembled at Dehra Dun in December 1954 was the fourth in the series and the first to be held outside Europe. Earlier Congresses had been held at Rome in 1926, at Budapest in 1936, and at Helsinki in 1949.

The offer by India to receive the Congress in 1954 was particularly appropriate and was very happily, efficiently, and generously put into effect. To the vast range and value of her forest estate and her great background of forest research and of management was added the pleasure of seeing her in action as one of the great independent nations of the world. The date chosen further enabled some old servants of India to come back and to meet old friends again before memories had faded. To those on their first visit the glimpses given of sal, teak, and deodar must indeed have been impressive. It was, alas, too early to see trees in flower, with one notable exception, *Terminalia myriocarpa*, which was in its full glory everywhere.

The staff work for these Congresses is now undertaken by the Food and Agricultural Organization of the United Nations. Recommendations made by the Congress generally take the form of requests to F.A.O. to assist with staff, funds, and with organization, and a fairly satisfactory account was rendered of progress made since the last meeting. At Dehra a certain amount of 'jungle clearing' was done in committee to clarify the purpose of World Forestry Congresses and their position in relation to the various international bodies. It was held that the Congress was a forum for the exchange of views which, while acting purely in an advisory capacity, might formulate broad recommendations on a regional or on a world-wide basis, which would be of assistance to governments and to particular international organizations. The venue for the next meeting was not fixed, but 1960 was suggested as a date and details will be settled by a preparatory committee of countries at the next F.A.O. meeting in Rome.

Turning to the main business of the meeting, most aspects of forestry were discussed and the papers submitted considered. There was a very full discussion on tropical forestry. Some progress was made by committees on Forest Terminologies and Multi-lingual Dictionaries in which the Commonwealth Forestry Bureau is to play a considerable part, and on all these summary reports were issued and recommendations made.

Some of the most urgent problems were those included under Protection. There is considerable anxiety over the spread of arid conditions in Rajasthan, while serious losses have been caused by flooding in many parts of India and notably in northern Bengal where much good land has recently been permanently overlaid with riverborne stones and rendered useless. The reclothing of degraded soils is a widespread problem in India and indeed all these problems are of worldwide importance. There is need for further research and need for education in land use. The Congress pointed out how little we really know about the effects of the forest and of forest grazing on soils, water, climate, &c.—as was revealed recently in a dispute over the effect of afforestation on a water supply, and they recommended that research on 'Forest Influences' be undertaken by F.A.O. in collaboration with I.U.F.R.O. and U.N.E.S.C.O. The Congress noted how difficult and how expensive the reforesting of degraded soils could be and how unsuitable it was to undertake planting without adequate pilot schemes and before considerable research had been carried out. They pointed out that, while techniques had been worked out for podzols and for marshy lands in the temperate and cold zones, the reforesting of denuded laterite soils in the tropics and the alkaline soils of arid zones still presented formidable problems.

THE OCCURRENCE OF PODZOLS UNDER DECIDUOUS WOODLAND IN THE NEW FOREST

By G. W. DIMBLEBY and J. M. GILL

SUMMARY

Examination of the soils of six small unenclosed oakwoods, all on the Plateau Gravels of the New Forest, showed that two of them were essentially brown forest soils, but the other four had pronounced features of podzolization. Pollen analysis revealed that the four podzolized ones had once borne heathland, whereas the other two had no such history. Particular attention was paid to the state of the humus layer in each wood. Those with brown forest soils maintained mull humus, probably by virtue of their mixed floristic composition. For those woods which had developed from heath it was demonstrated that holly was a pioneer species which, through its litter, could convert raw humus to mull humus, so that these woods showed mull conditions at the surface of what otherwise appeared to be a heath podzol. In both types of wood beech had become established avificially, and under old trees raw humus formation with attendant podzolization was demonstrated. It is suggested that the natural climax on these poor gravels is still an oak-dominated forest in equilibrium with a brown forest soil. Podzolization is a secondary condition.

INTRODUCTION

THE status of deciduous forest on the more acid and freely drained soils in Britain is a matter of some conjecture since so little of it remains and what does occur is usually drastically modified by biotic agencies. Nevertheless, it seems certain that the heathlands, which now typically occupy such sites, are themselves secondary and that the primary vegetation was in fact deciduous forest of some type. It also has been demonstrated that the soils occurring under such forest were of the brown forest type (Dimbleby (4)).

It is a matter of some importance in British forestry to decide whether or not the brown forest soil is still a stable soil on base-poor freely drained sands and gravels, or whether it will inevitably degenerate to a podzol whatever the vegetation that can be established on it. Not infrequently one finds that blocks of oakwood in heathland areas are in fact on well-defined podzols, suggesting that even under deciduous canopy podzolization is the predominant process on such soils. This paper describes a critical inquiry into the validity of such a conclusion, based upon the evidence provided by some small oakwoods in the New Forest, Hampshire.

SELECTION OF SITES

It was considered important to restrict observations to one parent material only, since others, though they may be undergoing similar processes, may be doing so at different rates. The Plateau Gravel was chosen as being the most likely to degrade, as shown by the fact that almost everywhere it is dominated by heathland. Anderson (2) observed that the unenclosed woods were largely composed of sessile oak, from which he concluded that they 'indicate with certainty that there was an almost unbroken massif of sessile oakwood in the northern high-lying part of the New Forest up to relatively recent times'. For this reason attention has been concentrated on the unenclosed woods as being the most

likely to be natural in origin, although an allowance must be made for the depredations of grazing and browsing animals and sometimes even fire. Six small blocks of woodland were finally chosen, all predominantly oakwoods, all unenclosed, and all on or partly on the Plateau Gravel. Where the woods fall only partly on the gravel, the descriptions and details given below refer exclusively to that part. The woods chosen are:

Winding Stonard Wood (Anderson's No. XXXVI), about ¼ mile south-west of Ocknell Inclosure (Nat. Grid. Ref. 41/242110).

Stonard Wood (Anderson's No. XXX), ¼ mile north-east of Puckpits Inclosure (Nat. Grid. Ref. 41/259105).

North Noads Wood, ¾ mile due west of Dibden Purlieu (Nat. Grid Ref. 41/400060).

South Noads Wood, immediately south of the last (Nat. Grid Ref. 41/399057).

Fernycroft Wood, 1 mile east of Beaulieu Road Station (Nat. Grid Ref. 41/369057).

(N.B. Most of this wood is enclosed; the part studied is a small area outside the northern boundary of the inclosure.)

Berry Wood, immediately west of Oakley Inclosure (Nat. Grid. Ref. 41/214054).

It will be seen from the geological map that all these woods occur on or near the edge of the Plateau Gravel. This is almost inevitable in the northern part of the area where the gravel follows the ridges and seldom exceeds ½ mile in width. In any case, where heath has developed, patches of woodland are almost always marginal or in some such position that they are not subject to the full effect of the periodical fires which sweep the heath, and which indeed are responsible for its existence. In this particular case, however, the question arises as to whether the thinning out of the gravel, by enabling the tree roots to reach the underlying parent material, allows trees to grow marginally where they could not survive more centrally on the gravel caps.

It might be argued that deep roots reaching the underlying strata could absorb larger quantities of minerals than if they were rooting only in gravel. This objection is probably more theoretical than real for two reasons. Firstly, the gravels overlie Barton Clay (Stonard and Winding Stonard Woods) or Barton Sands (the other four) both of which offer considerable impedance to drainage (Reid (12) discusses this point particularly for Barton Sands) and therefore probably represent a less favourable rooting medium than the overlying gravel. Secondly, both these strata are themselves base-poor and may carry extensive heathy vegetation where they are exposed. In any case the geological evidence (Reid (12 and 13)) is that the gravels average only a few feet in thickness and soil pits dug in some of the larger heathland areas have shown a depth of gravel not very different from that in the selected woods. So it seems reasonable to assume that these selected sites serve as a basis of reference for the gravel areas as a whole.

Whilst the northern gravels are older than the southern series, it is justifiable to compare sites from each, since the southern ones were derived directly from the northern ones at a later date.

METHOD OF STUDY

The three principal points upon which data were collected for each site are:

(i) the present vegetative cover.
(ii) the soil profile, with particular reference to the present humus conditions.
(iii) the past history of the site as revealed by pollen analysis of the soil.

Preliminary observations having shown that good correlations could be obtained, it was considered desirable to make the study extensive rather than intensive. By cutting down the detail to the minimum it was possible to cover more sites than would otherwise have been the case since for one of us time was limited. The vegetation and soil descriptions are therefore given in general terms. The pollen analysis was the most time-consuming part of the work, and since it is not commonly employed in this manner, a few words of explanation are called for. It has been found that in acid soils pollen may be preserved for very long periods. In heath soils, for instance, pollen of hazel scrub which existed perhaps 2,000 years ago may still be found (Dimbleby (4)). This pollen is gradually washed down into the soil, so that its vertical distribution gives a key to its age. Thus a species whose pollen is predominantly in the deeper layers of the soil is likely to be older than one whose pollen is all in the top few inches. No precise dating can be obtained by this means and differing rates of washdown, as well as differing resistance to decomposition, complicate interpretation, but even so the method is very valuable for detecting major changes of vegetation in the past of which no other record exists today.

It should be pointed out that it is not normally possible to separate species by this means, so only the generic names are given. In the case of the Ericaceae, even the genera are not easily distinguished but the preponderance of grains in these counts was of Calluna.

The accompanying diagrams (Fig. 1) represent the proportions of each genus calculated as a percentage of the total pollen and spore count. Only those types relevant to the present problem have been included.

In presenting the data the sites are not dealt with geographically, but are taken in such an order that the conclusions to be drawn follow as logically as possible. This should facilitate the interpretation of the site descriptions which follow.

SITE DESCRIPTIONS

A. *South Noads Wood*

(i) *Vegetation.* The wood consists mainly of oaks (*Quercus*) of all ages, some of the older ones being well grown. Beech (*Fagus*) occurs through the wood in small quantity and as young trees only. Holly (*Ilex*) is evenly distributed through the wood and forms a definite understory, whilst birch (*Betula*) is also frequent, particularly along the east margin of the wood.

The ground vegetation was the richest encountered in any of these woods, and included:

Holcus mollis (large patches)	*Primula vulgaris*
Rubus fruticosus agg.	*Viola riviniana*

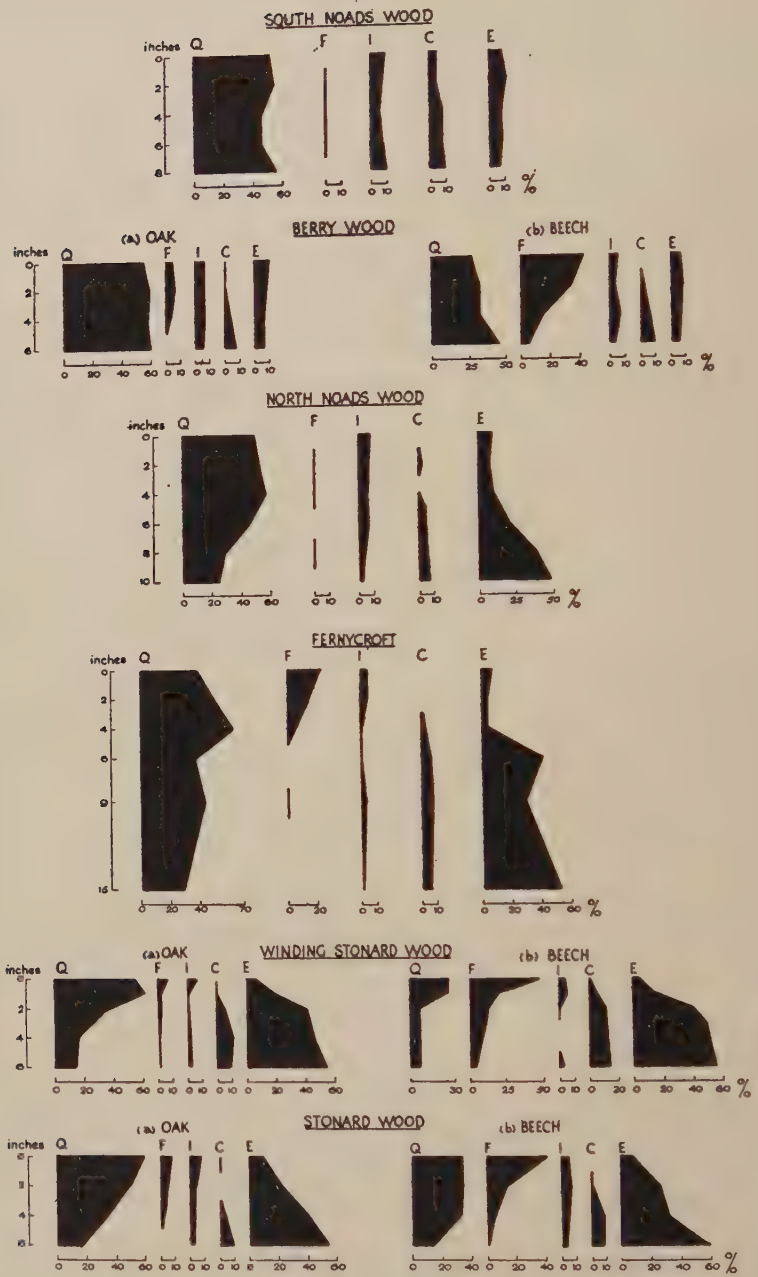


FIG. 1. Soil Pollen Profiles

(Q–oak; F–beech; I–holly; C–hazel; E–Ericaceae)

Oxalis acetosella	*Teucrium scorodonia*
Endymion nonscriptus	*Anemone nemorosa*
Hedera helix	*Lonicera periclymenum*

(ii) *Soil.* The soil is a brown forest soil, particularly rich in organic matter. Under the canopy of the oldest oaks there was slight evidence of leaching but where there was holly understory this was not visible. At about 1 foot the silty gravel gives way to a more clayey material.

(iii) *Pollen Profile.* The high and constant percentage of oak pollen is indicative of a long undisturbed history of oak dominance on the site; holly has been a constant associate. Hazel (*Corylus*), on the other hand, is poorly represented (it is in fact absent from the present-day flora) and has been more abundant in the past. The Ericaceae value is low throughout (cf. later values) and probably represents pollen drift from adjacent heathland.

B. *Berry Wood*

(i) *Vegetation.* The wood is variable in canopy, including some very large beech as well as some of the largest oaks seen on these gravels. A range of age is apparent among the oak; in fact regeneration is still taking place along the edge of the wood. Holly is uniformly distributed throughout the wood, except under dense beech canopy where it is shaded out. All stages of the killing of holly by the beech can be found here.

The ground vegetation is somewhat irregular in distribution. It is almost absent under the older oaks and the beech, but in gaps where these trees have fallen brambles may form dense thickets. Under the younger oaks *Pteridium* and *Deschampsia flexuosa* occur whilst at the edge of the wood *Vaccinium myrtillus* occurs where there is no holly. Other species present include:

Hedera helix	*Anemone nemorosa*
Lonicera periclymenum	*Oxalis acetosella*

(ii) *Soils.* In view of the floristic heterogeneity of the wood, soil profiles were examined under several contrasting vegetation types. Under the older oaks the humus is approaching the raw state (mor) and there is some visible leaching in the mineral soil. The soil under the old beeches is a podzol with raw humus on the surface. In contrast the soil under the younger oaks and also under the holly is a brown forest soil with a mull layer extending about 4 inches into the mineral soil.

(iii) *Pollen Profiles.* Pollen analysis was carried out on the two extreme soil types—the brown forest soil under the younger oak and the podzol under the old beech—and the two diagrams made an interesting comparison. Both show evidence of oak dominance amongst the deeper (and therefore older) pollen but whereas the former shows values of over 50 per cent. persisting to the surface, the latter shows the replacement of oak by beech in recent times.

This is confirmed by the fact that in the soil surface under the oak canopy there is 54 per cent. oak and only 4 per cent. beech pollen, whilst under the beech canopy there is 41 per cent. beech but 26 per cent. of oak. Since both trees are

generally assumed to have similar pollen production, this difference must indicate that on the sites where it is now dominant the beech succeeded oak. The same feature will be seen in other pollen diagrams from beech-dominated sites (e.g. Winding Stonard Wood).

Of the understory species holly is steady throughout both profiles, but again hazel is seen as a species of former times. Most significant, however, are low values of Ericaceae in both cases; again this is consistent with blown pollen from adjacent heathlands.

C. *North Noads Wood*

(i) *Vegetation.* The canopy is made up mostly of medium-sized oaks, though a few large ones are present. Beech is absent except for the occasional young colonizer. In the northern part of the wood birch becomes dominant and appears to be invading the heathland to the north of the wood. Holly is present, but in contrast to the woods so far described it is not uniformly distributed. It forms an intermittent fringe around the edge of the wood, in some places giving way to birch. Also present in this wood are a few old yew trees (*Taxus*), widely scattered.

The ground vegetation is sparse; *Deschampsia flexuosa* predominates, especially in the northern part of the wood under birch. Patches of bramble and ivy occur under the oak, and bracken may be found where the canopy is more open. There is no herb flora under the holly or the yew unless side-light can enter.

(ii) *Soil.* The gravel cap here, as in the adjacent South Noads Wood (A), is thin and the gravel is mixed with the underlying sand.

The upper 3 inches of the profile is mull and overlies about 4 inches of leached soil, beneath which is a well-developed humus pan. It is apparent from the state of the humus layer that podzolization is no longer the operative soil process on this site. The agency of podzolization must lie in the past.

(iii) *Pollen Profile.* An immediate contrast is presented between this profile and those so far examined. The value for the Ericaceae is so high in the lower layers of the profile that this can only be explained by the growth of heath species on this site. The corresponding drop in oak pollen confirms that this site has not a continuous history of closed woodland but has at some time been either heath or open woodland with ericaceous undergrowth. In either case, we need look no farther for the agency of podzolization. It is to be noted that beech has played no part in the past history of this site.

D. *Fernycroft Wood*

(i) *Vegetation.* The character of this wood which immediately strikes the eye is the close ring of holly which surrounds it, a more perfect development of the same tendency that was seen in the North Noads Wood. The main part of the wood consists of oaks and beeches estimated to be about 200 years old. Some younger specimens of both species were present but a number of these had been inexpertly felled. A few old pollarded beech also occur.

On the floor the vegetation is sparse; patches of bramble and bracken occur under gaps in the canopy, and these patches collect a good deal of leaf litter which

blows about freely. Also present are *Holcus mollis* and the bluebell (*Endymion nonscriptus*). Under the beeches and where the leaf litter has been removed by wind the moss *Leucobryum glaucum* forms its characteristic cushions.

(ii) *Soil.* The soil over most of the wood shows a clear podzol profile with a humus pan. Under the beech the humus is of the mor type, but under the holly, and to a lesser degree under the oak, the humus is of the mull type and the profile can be said to be regenerating. A number of molehills were noticed in the wood, indicating the presence of earthworms, and of those found one specimen was identified as *Lumbricus rubellus.*

Patches of unleached soil with no evidence of previous podzolization were found here and there through the wood.

(iii) *Pollen Profile.* This profile shows essentially the same features as the North Noads Wood. There is undoubted evidence of former occupation by heathland, though the drop in oak pollen is not so marked. It must be remembered, however, that this site adjoins a large block of permanent woodland, so that even if the site itself were under heath there would still be a copious supply of oak pollen.

E. *Winding Stonard Wood*

(i) *Vegetation.* This is another wood with a marked holly-ring, enclosing both oaks and beeches. The beech are mainly middle-aged or old, some pollarded; the older oaks are also pollarded, but there are some well-grown younger stems, especially on the southern edge of the wood. The holly flourishes under oak, but under beech it is sickly.

Under the oak a few patches of bramble occur together with ivy, *Oxalis acetosella*, and foxglove (*Digitalis*), but otherwise the vegetation is sparse. Butcher's Broom (*Ruscus aculeatus*) is to be found under the holly, but where the canopy is more open in the south of the wood there is bracken, bilberry (*Vaccinium myrtillus*), and *Deschampsia flexuosa.* Tufts of the moss *Polytrichum commune* occur under the beech.

(ii) *Soil.* Over most of the wood the soil has been podzolized, again with the development of a definite humus pan, though in the centre of the wood a patch of unleached soil several yards across was discovered. Under beech the humus is raw and matted, but elsewhere the trend seems to be towards mull formation, especially under holly, where a well-developed crumb structure has been produced. Earthworms were present in this mull layer.

(iii) *Pollen Profiles.* Two profiles were analysed for pollen, one under oak and the other under beech. Both show strong evidence of earlier heath vegetation, to the virtual exclusion of trees. Again it is seen that the beech followed oak, and therefore did not come in until the change from heath to oakwood had already been brought about.

F. *Stonard Wood*

(i) *Vegetation.* This is an almost perfect example of a holly-ring wood and in view of its interest from an historical point of view, as well as being a classic stand of old sessile oak, we would strongly support Anderson in advocating its preservation.

The centre of the wood is mostly occupied by large beeches, and these effectively exclude practically all vegetation except the mosses *Leucobryum glaucum* and *Polytrichum commune*. Outside the beech clump in the centre are oaks of greater age than the beech; one felled stem showed a ring count of over 200, and was probably about 250 years old. Towards the edge of the wood there is a range of younger age classes, even including seedlings. Under the oak the ground vegetation is better developed, though never abundant except under gaps, and includes ivy, bramble, bracken, and *Deschampsia*.

The holly ring at the edge of the wood appears to be extending outwards into the heathland, though seedlings are also found back inside the wood where canopy conditions allow. On the fringe of the wood young oaks may be seen coming up through thickets of holly, which gives them protection from grazing. On the heathland fires periodically destroy the holly shoots, but the stools sprout again and eventually some clumps become established.

(ii) *Soil*. Through the wood the soil profile is basically of the podzol type with a humus pan, but as in previous instances differing processes are going on in the humus layers dependent upon the immediate dominant.

Under the oldest oaks, where there is no associated vegetation, the oak litter appears to be forming mor humus; there is no evidence of a mull horizon in the mineral soil, which is compacted at the surface. Even so, the raw humus under these oaks is not so matted, greasy and thick as that under the beech, which are themselves younger than the oak. The beech humus is knit together with a dense mesh of beech mycorrhiza, and appears to be devoid of soil mesofauna except for click-beetle larvae (*Elateridae*).

Under the younger oaks the humus state is transitional, being much looser and containing millipedes and a few small earthworms. In places a definite mull layer has developed.

The humus under the holly ring is crumby, and of the mull type. Earthworms are abundant, the species identified being *Lumbricus rubellus* and *Bimastus eiseni*. It is interesting to note that even under isolated holly clumps surrounded by heath earthworms were consistently present, though totally absent a few feet away under the heath vegetation.

(iii) *Pollen Profiles*. Again two profiles are presented, one under beech and one under oak. The interpretation is essentially the same as for Winding Stonard Wood. Again evidence is provided of the recency of beech, as indicated both by the vertical distribution of the pollen and by the high proportion of oak pollen (33 per cent.) even under beech canopy.

DISCUSSION

It must be made clear at the outset that the conclusions reached in this paper and the points raised in this discussion should be regarded as appertaining only to poor, freely drained soils and possibly only to the conditions met with in southern England. To apply them indiscriminately to other soils and to other regions without some check in the field may be entirely misleading.

In selecting unenclosed woods for this study the factor of silvicultural treatment was probably reduced to a minimum, but disturbance in the form of grazing must be allowed for; the woods are all freely entered by the forest ponies. In certain cases the ground can be greatly modified by trampling, but as a rule this effect is localized. Another limitation of these woods for the purpose of study is their small size; a consequence of this is that in woods with little understory windblow of leaf litter is a disturbing factor. This was particularly noticeable in Fernycroft and North Noads Woods. However, making due allowance for such disturbance it does appear that the sites investigated illustrate clearly the main trends which have taken and are taking place.

The woods fall clearly into two categories: those that show little or no visible leaching where oak is the dominant and those that show a fully developed podzol profile. This distinction is matched exactly by the evidence of the pollen analyses that the former have never been under heath whereas the latter have. There is no evidence from the sites described that continuous oak forest has produced a podzol profile on these poor gravels.

With beech the situation is different. In Berry Wood there is a podzol under beech where there has been no previous history of heath occupation. The beech has followed oak within the last few centuries and the podzol must be attributed to the beech. This is a conclusion which can be confirmed over and over again, not only in the New Forest but wherever beech is growing on base-poor soils in Britain. It is relevant here to remember that Müller (8) ascribes the formation of the Jutland heaths very largely to this degrading effect of beech. It must be regarded as a species alien to these woods, at any rate as more than a casual occurrence. Anderson believes that the species has only been introduced into the New Forest in recent centuries, and the observations reported here fully confirm that. Anderson's (1) contention that beech is spread avificially satisfactorily explains its appearances in these woods. Its influence is to be regarded as an indirect result of man's activity, and the evidence suggests that the tree has no permanent place in the ecological system on these soils. In its transient passage, however, it is leaving a trail of site degradation behind it.

It is a feature of the beech when growing in pure groups that it forms virtually a mono-specific community; little else can grow with it. Its effect on the soil can therefore only be attributed to its own litter. This is not so true of the oak; rarely does it completely exclude all other species, especially in the shrub and field layers. In our conclusions above we have more or less acquitted oak forest of degrading the soil, but in doing so we have not necessarily acquitted the oak alone. In South Noads Wood, which must be regarded as the yardstick by which all the others should be judged, the soil is a brown forest soil showing little degradation; any degradation there is may reasonably be attributed to the undoubted disturbance to which even this wood has been and is being subjected. For example, hazel may be a key species; it certainly was once present but is not there now, and Young (14) attributes its disappearance to browsing. It was noticeable in the field that under the oldest oaks there was visible leaching. This was also recorded in Berry Wood, and in Stonard Wood it was observed that under old oak the humus

was raw. Under these large oak crowns there is a condition parallel to that of beech—the pure litter is falling unmixed with that of other species for many decades. In these circumstances the oak must also be suspected of producing an unfavourable humus type, though to a much less serious extent than the beech.

Of other species present in these woods, *Taxus* appears to be in a similar category, and it is another species which excludes other vegetation by its shade. Birch has not been seen in sufficient quantity to make a judgement in the New Forest, but in Yorkshire it has been shown to produce mull humus conditions (Dimbleby (5)): it usually permits considerable undergrowth. However, this question of associated species is not necessarily conclusive as the holly, which keeps the floor quite clear of other vegetation, is the chief agent of soil improvement in the New Forest.

This raises the question of the maintenance of a good soil type in the forest as a whole. Where the dominant trees are liable to cause degradation this can be achieved by an appropriate balancing with soil improving species, not only in the tree layer, but in the subordinate layers too. The richer flora of South Noads Wood is almost certainly correlated with the good soil conditions there; in Berry Wood, which is more disturbed, the flora associated with the oak was less rich and the brown forest soil less well developed. Müller (9) long ago related richness in species to humus condition on poor sands in Jutland, an exact parallel with these observations. The uncontrolled grazing by ponies and deer would greatly modify the flora and the effect will have been intensified in the unenclosed woods by the exclusion of the animals from inclosures.

The local abundance of holly with its fortunate combination of a good litter type with protection against browsing has probably been the main factor in allowing oak woodland to persist and even extend itself in the face of continued grazing, but the woodland so produced shows a lack of balance between soil-degrading and soil-improving species, since the latter happen to be most frequently shrubs or herbs.

As pointed out in the Introduction there is so little woodland left on the very poor gravels and sands in this country that its present-day status is largely unknown. The foregoing observations, however, serve to indicate that the oakwoods of the New Forest can persist even under unfavourable biotic influences and that when they do so they maintain a brown forest soil. This is in keeping with the views of Duchaufour (6) on the status of the brown forest soil in the Atlantic oakwoods of France, which, he maintains, only degrades if the forest is disturbed by biotic influences. Duchaufour follows Pallmann (10) in believing that the forest in the course of its development makes its own soil conditions and that these are very largely determined by climate and vegetation and only to a lesser degree by parent material.

The continental association which most nearly approximates to the original forest on these soils is the *Querceto-Betuletum*, which in Switzerland, according to Etter (7), develops a lightly podzolized brown earth. Pallmann, Richard, and Bach (11), however, point out that this association may result in a strongly podzolized brown earth and emphasize that this state is not due to human interference with

the association but is the natural product. Likewise in Germany, according to Braun-Blanquet (3), Tüxen postulates the *Querceto-Betuletum* as being the climax in north-west Europe succeeding the *Querceto-Carpinetum* as the soil becomes increasingly acidified and podzolized.

As far as can be seen from the trends on English acid soils the commencement of podzolization (as distinct from leaching) is always attributable to disturbance of the forest equilibrium, often originally in prehistoric times, and this would seem to accord with Duchaufour's views for the French Atlantic oak forest. Once podzolization has started it is difficult to see how it can fail to proceed unless a new balance of vegetation is introduced. Thus the lightly podzolized brown earths will eventually become strongly podzolized brown earths and ultimately the question must arise whether the *Querceto-Betuletum* will not itself be replaced by something else.

The brown forest soil is undoubtedly at its least stable on the base-poor soils, but this is all the more reason for being absolutely certain of the history of interference, direct or indirect, recent or ancient. However, the fact that natural succession on such parent rocks in Britain regenerates the brown forest soil even after heathland podzols have been formed is grounds for believing that here the brown forest soil is the mature soil under the deciduous forest which forms the climax.

Finally, brief mention may be made of the sequence of re-establishment of those woods which occupy sites previously under heath. All these four woods have developed a more or less complete holly ring and in view of what has been said above it seems likely that the holly is gradually invading the surrounding heathland and allowing the oak to follow it. This ring structure appears to be characteristic of the expanding woods and contrasts with those sites which have not been heathland where the holly is diffused throughout the wood. The restriction of the holly to the periphery suggests that the holly is not able to compete successfully under the shade of the developing oak in contrast to the primary woods where the canopy is more broken. In most cases, where one would have expected the holly to come in again in the centre as the trees matured, this has been prevented by the introduction of beech, and until the beech itself gets overmature the holly will be unable to come in. The stage appears to have been reached in Stonard Wood where there is some seeding of holly back into the wood.

In two of the woods, Fernycroft and Winding Stonard Woods, patches of unleached soil were encountered, which may be significant in interpreting the origin of these woods. These patches cannot have been occupied by heathland for any great length of time or they would have been podzolized. They must therefore have been protected by a patch of mull-forming vegetation. Müller (9) has described similar islands of mull humus under isolated oak bushes on the Jutland heaths; alternatively, and possibly more likely here, a clump of holly may have remained. In any event, it seems that a nucleus of woody mull-forming vegetation may have persisted and asserted itself centrifugally to produce the characteristic holly-ring structure. Whether such a nucleus is a prerequisite for the establishment of woods on heathland is a point upon which this study sheds no light.

CONCLUSIONS

1. The presence of the podzol profile under oak on the Plateau Gravels of the New Forest is due to the earlier occupation of the sites by heath.
2. Where there is no evidence of heath occupation (and where beech has not been introduced) the oakwood remains mixed floristically and structurally and maintains a brown forest soil.
3. Oak litter falling pure for a long period may eventually produce raw humus and start podzolization.
4. From 2 and 3 above it follows that the shrub and ground flora play an important part in maintaining mull conditions.
5. Beech litter produces an intractable mor and institutes podzolization.
6. Holly litter brings about the conversion of raw humus—even Calluna raw humus—to mull humus.
7. The fact that the regeneration of mull from mor is taking place wherever natural succession is leading back to oakwood indicates that the climate is not inhibitory to this process. There is no reason, therefore, to doubt the potential stability of the brown forest soil under present-day conditions on these poor gravels.

ACKNOWLEDGEMENTS

The authors express their thanks to those members of the Forestry Commission staff who were so helpful in providing information from Forestry Commission records; and also to Dr. J. E. Satchell for his kindness in identifying earthworms for us.

REFERENCES

(1) Anderson, M. L.: 'Avificial Woods arising from the Dissemination of Seed by Birds'. *Sylva*, No. 30, 9–12 (1949/50).
(2) —— 'Distribution of the Sessile Oak in the New Forest, Hampshire'. *Forestry*, xxiv. 79–113 (1951).
(3) Braun-Blanquet, J.: *Plant Sociology*, New York (1932).
(4) Dimbleby, G. W.: 'The Historical Status of Moorland in North-east Yorkshire'. *New Phyt.* li. 349–54 (1952).
(5) —— 'Soil Regeneration on the North-east Yorkshire Moors'. *J. Ecol.* xl. 331–41 (1952).
(6) Duchaufour, P.: 'Le climax du sol de la Chênaie Atlantique française'. *Schweiz. Zeitschr. Forstw.* ciii. 201–11 (1952).
(7) Etter, H.: 'Pflanzensoziologische und bodenkundliche Studien an schweizerischen Laubwäldern'. *Mitt. Schweiz. Anst. forstl. Versuchsw.* xxiii. 7–132 (1943).
(8) Müller, P. E.: 'Studier over Skovjord'. *Tidsskrift for Skovbrug*, iii (1879).
(9) —— 'Studier over Skovjord II'. Oum Muld og Mor i Egeskove og paa Heder. *Tidsskrift for Skovbrug*, vii (1884).
(10) Pallmann, H.: 'Über Waldböden'. *Beih. Zeitschr. Schweiz. Forstverein.* No. 21, 111–40 (1943).
(11) ——, Richard, F., and Bach, R.: 'Über die Zusammenarbeit von Bodenkunde und Pflanzensoziologie'. *C. R. 10th Congress Intern. Union For. Res. Org.* 57–95 (1948).
(12) Reid, C.: *The Geology of the Country around Southampton.* Mem. Geol. Surv. Eng. Wales (1902).
(13) —— *The Geology of the Country around Ringwood.* Mem. Geol. Surv. Eng. Wales (1902).
(14) Young, D. W.: 'The New Forest'. *Forestry*, ix. 1–16 (1935).

THE INFLUENCE OF WEATHER ON THE FREQUENCY OF BEECH MAST YEARS IN ENGLAND

By J. D. MATTHEWS
(*Forestry Commission*)

SUMMARY

Records are collected of beech masts (*Fagus sylvatica* L.) for the period 1921–50 and these records are compared in a table with the temperature, rainfall, and sunshine figures of the 5 months, May to September, of the preceding summer. It is shown that there are significant correlations between the size of mast and (i) July air temperature and (ii) July sunshine. Other factors affecting mast are considered and in particular the damaging effect of spring frosts to the flowers of beech.

INTRODUCTION

A SUMMARY of the seed supply position for the principal tree species appeared in the Forestry Commissioners' Thirtieth Annual Report (Forestry Commission (17)). Beech, *Fagus sylvatica* L., was included among those species 'in which a more or less complete failure of the seed crop occurs sufficiently frequently to be a serious embarrassment'. The difficulty in the case of the three conifers mentioned in that report [Douglas fir *Pseudotsuga taxifolia* (Poir.) Rehder., Sitka spruce *Picea sitchensis* (Bong.) Carr., and Japanese larch *Larix leptolepis* (Sieb. and Zucc.) Murr.] 'can be more or less met by storage, but it is not yet possible to hold over beech nuts'.

The quantity of seed produced by a given species is, according to Schlich (33), dependent upon (1) the average yield of each seed year; (2) the frequency of seed years.

The frequency of seed years is dependent mainly on external weather conditions and to a lesser extent on inherent tendencies. This paper attempts to demonstrate the effects of the three meteorological elements temperature, rainfall, and sunshine on the frequency of beech mast years in England during the period 1921–50.

THE PRODUCTION OF BEECH MAST IN ENGLAND, 1921–50.

Table I shows the production of mast by beech in England during the three decades 1921–30, 1931–40, and 1941–50. The data were gathered from four main sources:

1. The Reports on the Phenological Observations in the British Isles published by the Royal Meteorological Society.
2. The Annual Reports of the Forestry Commissioners.
3. The Foresters' Records published by the Royal English Forestry Society.
4. Papers by Watt (36), Dallimore (15), Bourne (2), Hyde (27), and others.

TABLE I. *The production of mast by beech in England*

Year of crop	*Size of crop*	*Authorities*	*Notes*
1921	Failure 0	F.C. (16)	..
1922	Very good 5	Clark (5), Watt (36), F.C. (16)	General. Good mast on the Continent
1923	Failure 0	F.C. (16)	..
1924	Good to very good 4–5	F.C. (16)	..
1925	Very bad 1	Clark (6), F.C. (16)	..
1926	Good 4	F.C. (16)	..
1927	Failure 0	Clark (7), F.C. (16)	Reports variable, probably due to local frost effects
1928	Poor 2	F.C. (16)	Flowers damaged by cold spells in mid-April and May
1929	Good to very good 4–5	Clark (9), F.C. (16)	..
1930	Failure 0	Clark (10), F.C. (16)	..
1931	Very bad 1	Clark (11), F.C. (16)	..
1932	Poor 2	F.C. (16)	..
1933	Poor–moderate 2–3	Clark (13), F.C. (16)	..
1934	Good to very good 4–5	Clark (14), Dallimore (15), F.C. (17)	A good year for fruit setting and fruit ripening
1935	Very bad to poor 1–2	F.R. (19), Margary (29), F.C. (17)	Damage by frost extensive but flowers on trees in some localities escaped
1936	Moderate 3	F.R. (20), Gunton (24), F.C. (17)	Conflicting evidence. Crop recorded as both poor and good
1937	Very bad 1	F.R. (21), F.C. (17)	Heavy crops on trees which did not bear in 1936
1938	Poor 2	F.R. (22), Gunton (25), F.C. (17)	Flowers of beech damaged by cold dry weather in late April–early May
1939	Poor 2	F.R. (23), F.C. (17)	..
1940	Poor 2	F.R. (23), F.C. (17)	..
1941	Poor 2	F.C. (17)	..
1942	Moderate to good 3–4	Hyde (27), F.C. (17)	..
1943	Failure 0	Hyde (27), F.C. (17)	..
1944	Good 4	Hyde (27), Gunton (26), F.C. (17) Bourne (2),	Good mast on the Continent
1945	Failure 0	Hyde (27), F.C. (17)	..
1946	Moderate to good 3–4	Hyde (27), F.C. (17)	..
1947	Poor 2	Hyde (27), F.C. (17)	..
1948	Very good 5	Hyde (27), F.C. (17)	Good mast on the Continent
1949	Very bad 1	..	..
1950	Very good 5	..	..

The data presented refer only to the main concentrations of beech woodlands in England. These concentrations are the South Downs beechwoods (Sussex and Hampshire), the Chilterns beechwoods (Buckinghamshire and Oxfordshire), and the Cotswolds beechwoods (Gloucestershire). Some data exist for other parts of England and for Scotland and Wales but these proved to be insufficient for attempting the correlations which are described in this paper. The latter data can, however, be used as the basis for certain general statements about the frequency and distribution of beech masts in the whole of Great Britain.

The beechwoods of the South Downs, Chilterns, and Cotswolds are almost all sited within or close to the boundaries of the Meteorological District 5 (England, South-east) used by the Meteorological Office in preparing their Monthly Weather Reports (31). The correlations made between beech masts and weather conditions have therefore been based upon weather data from Meteorological District 5.

The description of the size of the crop is based upon an arbitrary scale as follows:

0. Failure of crop. No beech nuts.
1. Very bad crop. Nuts in small quantities here and there on the outskirts of beech woods and on isolated individual trees, but almost none within the woods.
2. Poor crop. Slight general fruiting on the outskirts of beech woods and on isolated individual trees; poor fruiting within the woods.
3. Moderate crop. Moderate general fruiting on the outskirts of beechwoods and on isolated trees; slight general fruiting within the woods.
4. Good crop. Abundant general fruiting on the outskirts of beech woods and on isolated trees; good general fruiting within the woods.
5. Very good crop. Abundant general fruiting both on the outskirts of beech woods and on isolated trees and within the woods.

When transcribing records from the various sources a 'partial mast' has been taken as equivalent to a 'moderate' crop and a 'full' mast as equivalent to 'good' or 'very good' crops.

The defects of the records available are many, but agreement between the four main sources of information is general for most of the crop years. It would be an advantage for future studies of the kind described in this paper if future tree seed crop records could be standardized.

It will be seen from Table I that good and very good masts are produced at irregular intervals in England. Four good or very good masts were produced between 1921 and 1930, only one between 1931 and 1940, and three between 1941 and 1950. Two consecutive good or very good masts have never occurred during the period under review but two 'full' masts have been produced in three years on two occasions—namely in 1922–4 and 1948–50. Three good or very good masts were produced in the 5 years 1922–6 and a similar but not quite such a good run occurred during the period 1942–6. The longest interval between 'full' masts was the 10 years 1934–44. The average interval between 'full' masts for the 30-year period is 5 years.

Good and very good masts have almost invariably been followed by acute shortages or failures in the following year. This is in keeping with the commonly accepted theory that the trees need rest after carrying a heavy crop. Generally, however, beech appears to be capable of producing at least a moderate crop two seasons after the production of the good crop. A full 5-year cycle would appear to be: good to very good crop; failure to very bad crop; moderate crop; failure or very bad or poor crop; good to very good crop.

Table II compares this suggested 5-year cycle with the actual frequency of beech mast in each of the three decades under review.

TABLE II. *Summary of theoretical and actual frequency of beech mast in England*

Period Frequency	*Failure, very bad, and poor crops*	*Moderate crops (partial masts)*	*Good and very good crops (full masts)*
1921 Theoretical to 1930 Actual	5	2	3
	6	..	4
1931 Theoretical to 1940 Actual	5	3	2
	7	2	1
1941 Theoretical to 1950 Actual	5	2	3
	5	2	3
TOTALS Theoretical	15	7	8
Actual	18	4	8

Table II emphasizes the scarcity of beech nuts during the period 1931 to 1940. As will be shown later this can be attributed to damage to the male and female flowers by late spring frosts and to relatively low summer temperatures, relatively low incidence of sunshine, and relatively high summer rainfall during that decade.

Lindquist (28) concluded after observations on beech masts in Sweden that:

1. 'The flowering of beech is definitely periodic and autonomic and is also partly determined by external conditions.'
2. 'The inherent periodicity excludes abundant flowering every year but permits flowering every other year.'

The existence and importance of an inherent periodicity is difficult to determine. It appears from the data available that beech is prone to alternate year cropping in England. Biennial bearing in fruit trees has received considerable attention and there is still considerable divergence of opinion about the importance of the many factors concerned in the formation of flower buds (Singh (34)).

SUMMER WEATHER CONDITIONS AND THE PRODUCTION OF BEECH MAST

Tiren (35) points out that Schacht in 1860 was one of the first to show that the flower buds of many forest trees are formed during the year prior to

the flowering year and that in consequence the weather of the former year is probably important for flower bud differentiation (and subsequent formation of fruit). Busgen, Munch, and Thomson (4) quote various authors in support of the statement that abundant flower buds are only formed on beech during hot, dry summers. During the period of over one hundred years from 1811 to 1922 the great and lesser beech mast years on the Continent have followed on years with great summer drought. Lindquist (28) concludes from Swedish data that the

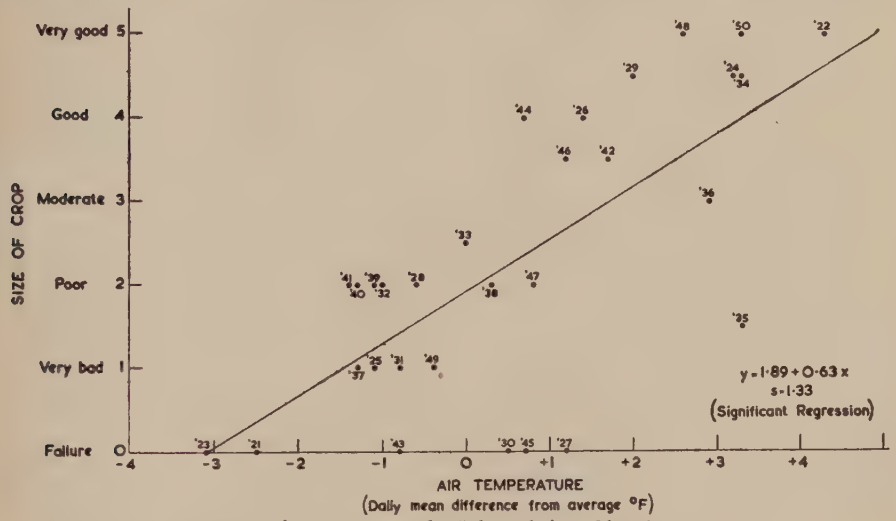


FIG. 1. Air temperature for July and size of beech mast.

character of the flowering (of beech) is influenced by the temperature of the preceding summer. Baldwin (1) records that in 1931 beech, elm, and ash seed was unusually abundant in the central United States one year after a severe drought. A similar sequence occurred in America in 1909. Watt (36) concluded from a study of beech mast years in Britain from 1887 to 1922 that a mast year was invariably preceded by a year with rainfall less than average although every dry year was not invariably followed by a beech mast. Watt's data suggested 'some direct or indirect connexion between rainfall and the production of mast'.

Table III gives the temperature, rainfall, and sunshine figures for Meteorological District 5 for the 5 months May to September and also the beech mast of the following year. Each of these three meteorological elements are discussed in detail below.

TEMPERATURE AND THE PRODUCTION OF BEECH MAST

The mean daily differences from the average air temperatures for each of the 5 months May to September have been plotted against the size of the beech mast of the following year.

The regressions of size of mast on air temperature for the months of May, June, August, and September are not significant. The regression for July is significant ($y = 1{\cdot}89 + 0{\cdot}63\,x$; $s = 1{\cdot}33$; see Fig. 1). Thus the higher the mean daily

TABLE III. *Meteorological data for district 5 during the 5 months May to September and for the year and size of beech mast in the following year*

Weather of the year	Air temperature: Daily mean difference from average						Rainfall: Percentage of average (1881–1915)						Sunshine: Percentage of average (1881–1915)						Crop Year	Size of Crop
	May	June	July	August	Sept.	Year	May	June	July	August	Sept.	Year	May	June	July	August	Sept.	Year		
1920	+2·1	+1·1	−2·5	−3·6	−0·2	+1·0	84	97	194	66	132	95	98	95	66	83	67	87	1921	Failure
1921	+1·2	+1·0	+4·3	+0·8	+2·5	+2·4	69	7	13	61	59	51	108	109	127	87	114	111	1922	Very good
1922	+3·5	+0·2	−3·1	−2·8	−1·7	−0·5	55	74	140	115	113	102	136	107	74	70	81	95	1923	Failure
1923	−1·9	−2·7	+3·2	+0·2	−1·0	+0·1	127	22	64	101	90	104	77	66	116	128	125	98	1924	Good to very good
1924	+1·5	+0·1	−1·1	−2·3	+0·3	+0·2	225	117	159	116	186	128	98	97	115	87	82	98	1925	Very bad
1925	+1·0	+1·6	+1·4	0·0	−3·1	+0·2	156	9	150	103	146	111	101	137	95	83	91	103	1926	Good
1926	−1·0	−1·1	+1·2	+1·6	+3·3	+1·2	106	148	80	54	40	103	83	99	88	104	89	90	1927	Failure
1927	+1·3	−2·1	−0·6	+0·2	+1·1	+0·2	44	164	179	165	242	133	113	84	69	92	74	74	1928	Poor
1928	−0·4	−1·3	+2·0	+0·3	−0·4	+1·1	108	117	80	84	45	114	87	111	137	107	146	112	1929	Good to very good
1929	0·0	−1·2	+0·5	+0·2	+5·4	−0·3	95	71	75	85	24	97	119	106	124	105	134	116	1930	Failure
1930	−0·4	+2·3	−0·8	+1·0	+0·7	+0·9	140	53	105	148	168	114	78	115	94	118	87	99	1931	Very bad
1931	+0·5	+1·4	−1·0	−1·3	−3·2	−0·2	148	92	159	184	89	99	83	97	80	78	88	90	1932	Poor
1932	−1·1	−0·3	0·0	+4·2	+0·5	+0·4	243	58	147	54	135	100	59	106	73	107	70	87	1933	Poor to moderate
1933	+2·1	+2·0	+3·3	+4·1	+3·3	+1·1	91	83	80	48	175	80	85	120	119	132	121	115	1934	Good to very good
1934	+0·8[1]	+1·6	+3·3	−0·2	+2·3	+1·2	50	64	69	100	80	92	109	105	136	105	120	104	1935	Very bad to poor
1935	−1·9	+1·3	+2·9	+1·7	+1·3	+1·2	74	162	52	124	199	124	92	100	136	109	102	102	1936	Moderate
1936	+0·8	+1·5	−1·3	+0·9	+1·9	+0·4	25	164	168	37	136	105	97	97	74	99	76	90	1937	Very bad
1937	+2·0	+0·7	+0·3	+2·8	+0·5	+1·1	134	80	52	72	113	126	86	105	71	109	105	92	1938	Poor
1938	−1·5	+1·1	−1·1	+1·6	+1·3	+1·5	110	42	87	100	103	89	82	107	78	90	90	100	1939	Poor
1939	−0·2	+0·1	−1·3	+1·3	+2·0	+0·9	73	77	129	95	64	126	105	109	88	99	117	102	1940	Poor
1940	+2·2	+3·8	−1·4	+0·5	−0·4	−0·1	51	38	126	3	78	107	117	135	96	113	119	109	1941	Poor
1941	−2·3	+1·1	+1·7	−1·4	+1·2	−0·1	103	82	135	185	26	101	78	109	116	98	88	95	1942	Moderate to good
1942	−0·4	+0·6	−0·8	+1·0	+1·3	−0·4	171	23	86	118	92	97	99	128	83	84	91	98	1943	Failure
1943	+2·3	+0·3	+0·7	+1·3	0·0	+1·7	126	64	77	68	88	84	117	102	96	107	105	106	1944	Good
1944	+0·2	−0·7	+0·7	+3·4	−1·2	+0·6	31	74	95	97	122	89	118	93	63	111	100	99	1945	Failure
1945	+2·2	+0·9	+1·2	+0·7	+1·9	+2·1	125	101	99	76	91	83	94	101	102	84	53	97	1946	Moderate to good
1946	−1·1	−1·5	+0·8	−1·2	+0·9	+0·5	175	131	90	191	161	119	89	81	108	84	77	93	1947	Poor
1947	+3·6	+2·9	+2·6	+5·9	+3·8	+0·7	74	114	92	18	55	81	86	105	93	142	110	100	1948	Very good
1948	+1·1	0·0	−0·4	−0·7	+1·1	+1·8	148	92	57	131	111	96	116	86	87	80	103	105	1949	Very bad
1949	−0·6	+1·3	+3·3	+3·0	+6·5	+2·7	118	22	41	50	99	83	108	125	130	119	104	122	1950	Very good

[1] Recomputed deviations using 1881–1915 averages calculated by the staff of the Meteorological Office.

temperature is in July the better is the beech mast of the following year. Temperatures during July are evidently more important than those during June and August, but it appears probable that favourable conditions during June and August intensify the effects of favourable conditions during July.

The mean air temperature for July in District 5 is 61·1° F. (Period 1881–1915). Thus it appears from the scatter diagram for July (Fig. 1) that July air temperatures in excess of 62° F. are required for moderate production of mast and in excess of 63° F. for good or very good crops. Mean temperatures greater than 63° F. were recorded in July 1949 for practically the whole of England south of a line from the Mersey to the Wash (31). The beech crop of 1950 in this area was generally very good.

The fact that late spring frosts, when the beech is in flower, may destroy the potential beech mast has been stressed by Watt (36), Lindquist (28), and Brown (3). Brown reports that flowers were destroyed in this way in parts of north-east England in May 1948. Lindquist quotes the work of Oppermann and Bornebush (32) who have shown that the female flower of beech is very sensitive to frost during the whole period of flowering and that the flowers are killed by temperatures of −1·4° to −3° C. (24·6° to 29·5° F.). The male flowers are damaged at −1° C. (30·2° F.).

Closer examination of the scatter diagram for July temperature and size of beech mast (Fig. I) reveals three major exceptions to the rule that a good mast follows on high July temperatures. These exceptions are 1927, 1935, and 1936. The temperatures of July 1926 and 1934 respectively were favourable to flower-bud formation, but these flowers were wholly or partially destroyed by late spring frosts in late April and early May of 1927 and 1935.

The explanation for the poor mast of the year 1936 is less clear. The months of July in the years 1933, 1934, and 1935 were remarkable for the excess of temperature. The beech mast was very good in 1934. The extent of flower formation in the spring of 1935 is not recorded, but the damage done to trees in general by the 1935 frost was very extensive. The reports about the mast of the year 1936 are very conflicting and it may be that this is due to the after-effects of the 1935 frosts. Flower production had probably not really returned to normal even by 1937 when it was recorded that there were heavy crops on trees which did not bear in 1936 (Gunton (24)).

RAINFALL AND THE PRODUCTION OF BEECH MAST

The figures of the percentage of average rainfall for each of the 5 months May to September have been plotted against the size of the beech mast of the following year. The regressions of size of beech mast on rainfall in these months are not significant. It must be concluded that while lack of summer rainfall evidently has a contributory effect it is not sufficient in itself to bring about the differentiation of flower buds in beech.

SUNSHINE AND THE PRODUCTION OF BEECH MAST

The figures of the percentage of average sunshine for each of the 5 months May to September have been plotted against the size of the beech mast of the

following year. The results are similar to those for temperature. The regressions for size of mast on sunshine for the months of May, June, August, and September are not significant. The regression for July is significant ($y = 0{\cdot}038x - 1{\cdot}41 : s = 1{\cdot}70$; see Fig. 2). Thus the greater the excess of sunshine in July the better is the

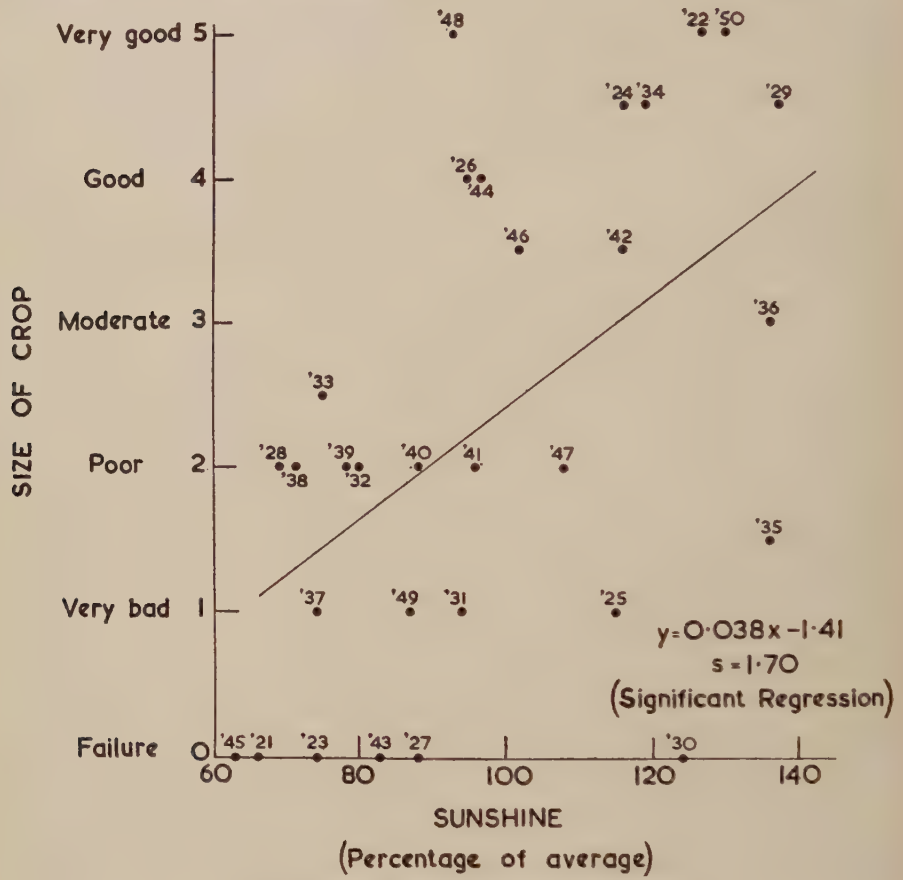


Fig. 2. Sunshine for July and size of beech mast

beech mast of the following year. Excess of sunshine during July is evidently more important than excess during June and August although it appears probable that favourable conditions during June and August will intensify the effects of favourable conditions during July.

To sum up—it appears that above-average temperatures and excess of sunshine in July are essential for the production of mast in beech. Lack of rainfall in July is not in itself sufficient to stimulate the production of mast but appears to supplement the effects of temperature and sunshine.

The precise time at which the differentiation of the flower buds of beech takes place has not yet been determined. Two items of indirect evidence are however available. The first is that the flower buds of beech are recognizable in September

(Busgen, Munch, and Thompson (4)). The flower buds of beech are much fatter and larger than the leaf buds. If they are recognizable in September the differentiation will probably have taken place at least a month and possibly 6 weeks earlier. The second item of evidence is that given in this report—that the temperature, sunshine, and rainfall of July have a considerable influence on the formation of flower buds.

It seems likely that differentiation takes place during August, but this statement can only be taken as a possible guide for future direct observational work.

SOME GENERAL OBSERVATIONS ON THE PRODUCTION OF BEECH MAST IN GREAT BRITAIN

Beech normally flowers during the period from the last 2 weeks in April to the first 2 weeks in May. The male and female flowers are therefore rather vulnerable to late spring frosts and the organization of future seed supplies must take account of this fact. Future seed sources such as seed stands, seed plantations, and seed orchards must be both carefully sited and fairly well scattered to reduce the risk of seed-crop failures due to late spring frosts.

Beech produces mast at irregular intervals throughout Great Britain, but the crop is not normally uniform throughout the country in the same year. Watt (36) records that in 1920 north-east Scotland had full crops while Sussex had only a partial crop. Severe spring frosts in parts of north-east England in May 1948 created a local shortage of nuts which contrasted sharply with the general high level of the 1948 beech mast over the country as a whole. In 1950 the beech mast was very good in the Cotswolds and noticeably smaller in quantity in the Chilterns. The South Downs occupied an intermediate position between the two extremes. This order of size of crop is not maintained in each mast year.

Watt (36) has also shown that mast production may be general over an area but not all trees of seed-bearing age produce seed. Trees in the open may bear a good crop of seed while those in close canopy bear none. Even isolated trees vary much in their productivity, some bearing mast while adjoining trees bear none. Brown (3) states that small-crowned trees in close canopy bear much less heavily than trees with large crowns in a stand which has been thinned. Bourne (2) found in 1944 that the quantity of seed was greatest where the proportion of trees with wide crowns was comparatively high. On large trees the abundance was greater on the relatively dry soils than on the moister soils.

The general picture is therefore one of considerable variation which adds to the difficulties of forecasting seed supplies and planning collection programmes. There is a strong case for selecting, reserving, and treating a considerable number of seed-collection areas (called for convenience Seed Stands) in the best mature woodlands and well distributed throughout the range of beech in Great Britain. These would form the main sources of mast and the supplies could be supplemented as required from other woodlands. Seed stands should not be restricted to one normally favourable area because of the high probability of local failure of the crop.

ACKNOWLEDGEMENTS

The writer is indebted to the Director of the Meteorological Office for permission to publish Table III; to Mr. I. J. M. Dawson for assistance in collecting data and to Mr. J. N. R. Jeffers for the statistical analysis of the data collected.

LITERATURE REFERENCES

(1) Baldwin, H. I. (1942): *Forest Tree Seed.* Chronica Botanica Co., Waltham, Mass., U.S.A.
(2) Bourne, R. (1945): 'Neglect of Natural Regeneration.' *Forestry*, xix. 33–40.
(3) Brown, J. M. B. (1953): *Studies on British Beechwoods.* Forestry Commission Bulletin No. 20. London, H.M.S.O.
(4) Busgen, M., Munch, E., Thomson, T. (1929): *The Structure and Life of Forest Trees*, p. 370. London, Chapman and Hall.
(5) Clark, J. E., and others (1923): 'Report on the Phenological Observations in the British Isles.' *Quarterly Journal of the Royal Meteorological Society*, xlix.
(6) (1926) Ibid. lii. (7) (1928) ibid. liv. (8) (1929) Ibid. lv. (9) (1930) Ibid. lvi. (10) (1931) Ibid. lvii. (11) (1932) Ibid. lviii. (12) (1933) Ibid. lix. (13) (1934) Ibid. lx. (14) (1935) Ibid. lxi.
(15) Dallimore, W. (1935): 'Notes on the Dry Seasons of 1933 and 1934.' *Quarterly Journal of Forestry*, xxix. 115–17.
(16) Forestry Commission (1934): *Fifteenth Annual Report of the Forestry Commissioners for the Year Ending September 30th 1933.* London, H.M.S.O.
(17) —— (1950): *Thirtieth Annual Report of the Forestry Commissioners for the Year Ending September 30th 1949*, pp. 48 and 103. London, H.M.S.O.
(18) Forester's Record (1935): 'A Forester's Record.' *Quarterly Journal of Forestry*, xxix. 2. 3, 107, 204.
(19) —— (1936): 'Forester's Record. Report for 1935.' Ibid. xxx. 3, 228–34.
(20) —— (1937): 'Forester's Record. Report for 1936.' Ibid. xxxi. 3, 189–95.
(21) —— (1938): 'Forester's Record. Report for 1937.' Ibid. xxxii. 3, 194–200.
(22) —— (1939): 'Forester's Record.' Ibid. xxxiii. 3, 187–95.
(23) —— (1940): 'Forester's Record.' Ibid. xxxiv. 116.
(24) Gunton, H. C. (1938): 'Report on the Phenological Observations in the British Isles.' *Quarterly Journal of the Royal Meteorological Society*, lxiv.
(25) —— (1939): Ibid. lxv.
(26) —— (1946): Ibid. lxxii.
(27) Hyde, H. A. (1951): 'Pollen Output and Seed Production in Forest Trees.' *Quarterly Journal of Forestry*, v. 3, 172–5.
(28) Lindquist, B. (1931): 'Den Skandinaviska Bogskogens Biologi' (The Ecology of the Scandinavian Beechwoods). *Svenska Skogs-Foren. Tidskr.* iii. 179–532 (English digest, 486–520).
(29) Margary, I. D. (1936): 'Report on the Phenological Observations in the British Isles'. *Quarterly Journal of the Royal Meteorological Society*, lxii.
(30) —— (1937): Ibid. lxiii.
(31) Monthly Weather Reports: *Monthly Weather Reports of the Meteorological Office.* H.M.S.O.
(32) Oppermann, A., and Bornesbusch, C. H. (1926): 'Fra skov og Planteskole 1–12.' *Dansk Skovforenings Tidsskrift* 8. Kobenhaven.
(33) Schlich, W. (1910): *Schlich's Manual of Forestry.* Vol. II. London. Fourth Edition 1910.
(34) Singh, L. B. (1948): 'Studies in Biennial Bearing II. A Review of the Literature.' *The Journal of Horticultural Science*, xxiv. 1.
(35) Tiren, L. (1935): 'Om Granens Kottsättning, dess periodicitet och samband med temperatur och nederbörd' (On the Fruit setting of Spruce, its Periodicity and Relation to Temperature and Precipitation). *Meddelanden från Statens Skogsförsöksanstalt*, No. 28 (English summary, 521–4).
(36) Watt, A. S. (1925): 'On the Ecology of British Beechwoods with Special Reference to their Regeneration. Part II, Sections II and III.' *Journal of Ecology*, xiii. 27.

THOUGHTS ON YIELD TABLES

By F. C. OSMASTON

SUMMARY

The author examines the recently published Forestry Commission Record *Revised Yield Tables for Conifers in Great Britain* and shows how the standing volume, basal area, numbers of trees, and mean quarter girth vary with the mean top-height irrespective of age and quality class. By analogy with the Indian Forest Record *Multiple Yield Tables for Deodar* (*Cedrus deodara*, Loudon), he concludes that treatment does not materially affect this relationship. A modified yield table for Sitka spruce (*Picea sitchensis* (Bong.) Carr.) based on mean top-height only is given.

YIELD tables, with their massed figures, tend to be forbidding documents that are consulted only for specific information such as the yield to be expected from one acre of woodland. Consequently on first reading the recently published *Revised Yield Tables for Conifers in Great Britain* (Hummel and Christie (2)), one may notice that one acre of fully stocked quality class I Norway spruce (*Picea abies* Karst.) provides a total yield, including thinnings, of no less than 10,310 hoppus feet after 50 years of growth. But if the stand were only quality class IV, the total yield would be a mere 3,950 hoppus feet. How erroneous calculations of volumes are if the quality class is mistaken!

There lies the snag. In order to use the tables for any stand of trees the quality or productivity class must first be ascertained. To assess the site quality one has to know not only the exact age but also the mean 'top-height', i.e. the average height of the hundred largest trees per acre. A knowledge of the mean height of *all* the trees could also be used. Moreover, the potential productivity of land varies from place to place so that a whole wood may contain two, three, or even more quality or productivity classes. Therefore, each should be assessed separately and this involves a knowledge of the area of each. Furthermore, a stand may easily lie between two quality classes. The difficulties involved in all this makes one wonder whether yield tables have any real practical value. Repeated enumerations with volumes calculated from suitable volume tables would give more reliable results and as easily. Even yield tables do not overcome the necessity of enumeration, as the basal area of the wood must be known for comparison with the yield table basal area per acre.

But further study of the yield tables demonstrates an interesting fact. If any one mean top-height is selected, the volume per acre is constant for that height, irrespective of quality class or age. How very convenient. If this is really true, it would be easy to calculate the standing volume in any wood by measuring the average height of the largest trees (the dominants, co-dominants, and a few sub-dominants), referring to the tables and making some allowance for the stocking of the stand. This is, of course, no new idea. Others have used it, in particular those who, taking an aircraft and a camera, fly over forests and photograph them. The heights of the trees depicted on the photograph are then estimated by eye or by the use of clever instruments and technique. With the aid of a density factor the volumes are then obtained from a volume table based on heights (Spurr (3)).

Clearly it is worth while to check the constancy of this relationship between height and volume per acre. The tables for Douglas fir (*Pseudotsuga taxifolia* Brit.) may be examined and, if possible, a curve drawn to show the relationship. Will it be a smooth curve? Similar heights in each quality class can be taken and averaged and their corresponding volumes also averaged. For example, in the British Yield Tables for Douglas fir in quality classes I, II, III, and V, top-heights of 46½, 47, 47, and 47 feet (averaging 46·875) are recorded. The respective volumes per acre are 1,720, 1,790, 1,810, and 1,790 (average 1,780) hoppus feet. In this way average top-heights and volumes over the whole range of heights (for all quality classes and ages) can be obtained and plotted, volume over mean top-height, on graph paper. The resulting curve is beautifully smooth—a gentle curve, concave upwards, becoming a nearly straight line after heights of about 100 feet. Volume seems to increase uniformly with but slightly more rapidly than height up to the limit of the tables.

A similar check with Scots pine (*Pinus silvestris* L.) (for which figures up to ages of 75 years against 50 years for Douglas) gave an even better fit to the data. And, *mirabile dictu*, the curve is apparently a straight line up to a height of 75 feet—much easier to draw. After a height of 75 feet the curve begins to dip slightly downwards. For the straight-line portion the formula for the curve is easy to solve. Thus, if V = the standing volume per acre and H = the mean top-height, then $V = aH+c$, where a and c are constants. For Scots pine these constants seem to have the values of 75·46875 or, say, 75·47 for a and −1,481·875 or, say, −1,482 for c. So, if the mean top-height of a stand is 60 feet, then the volume per acre for a fully stocked stand (of any age or quality class) should equal $(60\times 75{\cdot}47)-1{,}482 = 4{,}528{\cdot}2-1{,}482 = 3{,}046{\cdot}2$ hoppus feet. A reference to the yield tables will show a volume of 3,040 hoppus feet for quality II Scots pine with a top-height of 60 feet, aged 50 years. Similarly for quality III Scots pine with a mean top-height of 60½ feet the yield tables give a volume of 3,070 hoppus feet. (The extra ½ foot in height accounts for the extra 30 hoppus feet.)

For European larch (*Larix decidua* Mill.) the curve of volume/top-height is again very smooth, a very gentle curve slightly concave upwards becoming apparently straight from 65 to 100 feet. Sitka spruce gives a straight line up to a top-height of about 95 feet after which the curve tends to dip very slightly downwards. For the straight portion the constants a and c have values of 78·5 and −1,360 respectively. Testing these values in the formula $V = aH+c$, volumes of 4,194 and 2,565 hoppus feet per acre are obtained for stands whose mean top-heights are 70½ and 50 feet respectively. The yield tables give volumes of 4,180 and 2,570 hoppus feet respectively for quality I stands 27 years old, having 70½ feet top-height and quality V stands 35 years old with a top-height of 50 feet. The errors of the calculated volumes are only +⅓ per cent. and −⅕ per cent.

A more detailed examination of the tables shows that not only is there a very close relationship between the standing volume per acre and top-height, but that there is a similar relationship between top-height and the other variables, namely number of trees per acre, the mean quarter girth at breast height, the basal area per acre, and the total yield (including thinnings) per acre. So curves for each of

these variables were drawn against mean top-height as the independent variable, for Sitka spruce (Fig. 1). To avoid any arbitrary smoothing of the curves by taking average figures from the yield tables, each of the published data was plotted. Thus for standing volumes over heights, each of the entries under quality I was first plotted, then all those for quality II, and so on. This method did not disturb the smoothness of the curves. In this way smooth curves were drawn for number of trees per acre, mean q.g.b.h., basal area per acre, standing volume per acre, and total yield to date (including thinnings). From these curves the values of each of these variables were read off against 5-foot height classes from 30 to 115 feet, as shown in Table 1, *A Modified Yield Table.*

Using the curves it is therefore possible to tell what the basal area per acre, volume per acre, &c., should be for a stand of any top-height, irrespective of its age or quality class—provided the stand is fully stocked. From the table similar knowledge is available for any 5-foot height class. For example, a fully stocked stand of Sitka spruce which is 70 feet high should have a standing volume of 4,130 hoppus feet per acre, 315 trees per acre whose mean quarter girth is $7\frac{3}{4}$ inches, and a basal area of 133 hoppus square feet. The Forestry Commission Yield Tables for quality class V (with a height of 70 feet and an age of 50 years) give values of 4,140 hoppus feet, 315, $7\frac{3}{4}$ inches, and 133 hoppus square feet. Other similar comparisons can easily be made.

So far, so good. If the mean top-height of a stand is known, then, irrespective of its age or site quality, the modified yield table gives full information on its volume per acre, &c. (but not for increment)—provided the stand is fully or 'normally' stocked. The actual basal area of the stand must, therefore, be ascertained by either a total enumeration or a suitable sampling procedure. If the actual basal area is, for example, 75 per cent. of the 'normal' stocking as indicated by the table for the top-height of the stand, is it then justifiable to reduce the 'normal' volume by 25 per cent. and say that that is the true stand volume per acre? Can one, in other words, compute the actual volume from the indicated 'normal' volume by proportion of actual to 'normal' basal areas?

If the actual basal area differs from the 'normal' basal area shown in the table only because of some blanks which may exist and not because the stand has been subjected to thinnings uniformly heavier (or lighter) than those made in the stands from which the Forestry Commission collected their data, it is presumably perfectly justifiable to correct volumes by proportion of basal area. Otherwise the assumption is dangerous. The problem to solve, therefore, is whether *treatment* affects the relationship between mean top-height and volume, basal area, &c.

To study the effect of treatment on this relationship, yield tables that give figures for stands subjected to various thinning grades are required. None is yet available in this country. But some have been published in India, e.g. those for deodar in 1933 (Champion and Mahendru (1)). In these tables figures for seven quality classes, I, II, III, and IV, with intermediate classes I/II, II/III, and III/IV, are given. For each quality class data for four thinning grades (B, C, D, and E, of which E is the heaviest) are given.

In studying these deodar tables it is first necessary to test the validity of the

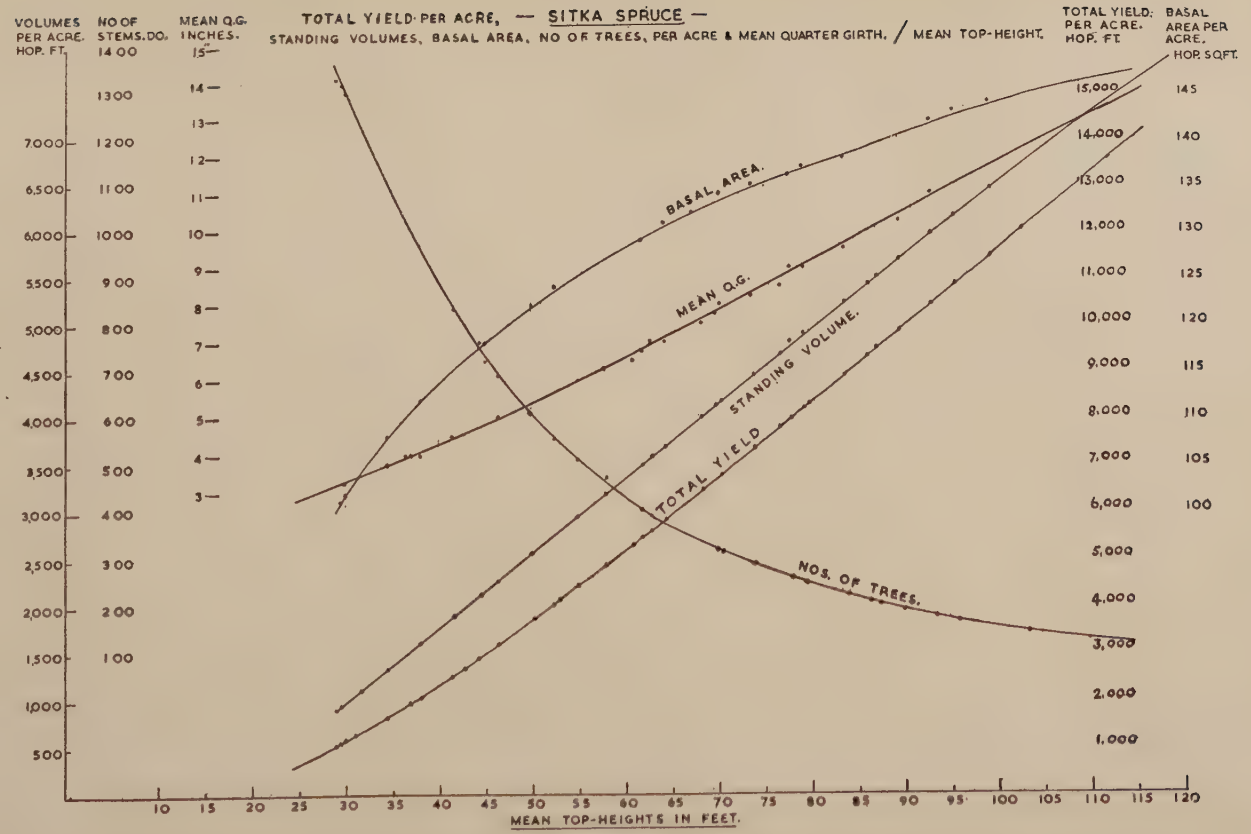

TOTAL YIELD PER ACRE, — SITKA SPRUCE —
STANDING VOLUMES, BASAL AREA, NO OF TREES, PER ACRE & MEAN QUARTER GIRTH. / MEAN TOP-HEIGHT.
VOLUMES PER ACRE. HOP. FT.
NO OF STEMS. DO.
MEAN Q.G. INCHES.
TOTAL YIELD PER ACRE. HOP. FT
BASAL AREA PER ACRE. HOP. SQ FT.
BASAL AREA.
MEAN Q.G.
STANDING VOLUME.
TOTAL YIELD
NOS. OF TREES.
MEAN TOP-HEIGHTS IN FEET.

FIG. 1

assumption that volumes (and other variables) have a definite relationship to height. The tables do not give the mean top-height but the mean stand height; but mean height should serve although mean stand height is affected by suppressed trees which may interfere with a true expression of volume/height, &c., in lightly thinned woods.

TABLE I. *A modified yield table for Sitka spruce. Based on top-heights only. Age and site variations excluded*

Top-height (feet)	*No. of trees per acre*	*Mean q.g.b.h. (in.)*	*Basal area per acre (hop. sq. ft.)*	*Standing volume per acre (hop. ft.)*	*Total yield to date per acre (hop. ft.)*	*Thinning yields per acre (hop. ft.)*
30	1,300	3¼	102	980	1,150	170
35	1,074	3¾	109	1,380	1,730	180
40	890	4¼	114	1,760	2,320	210
45	732	4¾	118	2,175	2,980	245
50	606	5¼	122	2,560	3,680	315
55	507	6	125	2,960	4,420	340
60	430	6½	128·5	3,340	5,150	350
65	365	7¼	131	3,740	5,920	370
70	315	7¾	133	4,130	6,700	390
75	275	8½	135	4,520	7,490	400
80	241	9¼	137	4,910	8,280	400
85	213	9¾	139	5,300	9,075	405
90	189	10½	140·5	5,690	9,875	410
95	168	11	142	6,075	10,675	415
100	150	11¾	143·5	6,450	11,475	420
105	137	12¼	145	6,830	12,275	425
110	125	13	146	7,200	13,080	435
115	113	13¾	147	7,540	13,860	440

Notes: mean q.g.b.h. to the nearest ¼ inch: basal area to the nearest ½ hop. sq. ft.

A somewhat superficial study of the tables shows that there is a definite relationship between mean height and volume and the other variables, but not such an exact relationship as shown in the Yield Tables for British Conifers. The relationship seems to be definite for any one thinning treatment irrespective of site or age, at least for the main range of heights, although there seem to be some discrepancies at the limit of heights in the lowest quality class. The authors of the deodar tables recognize this relationship between height and volume by giving a special table which shows for every 5-foot height class the 'normal' average volume to be expected for each of the four thinning grades—irrespective of age and quality class.

The next step is to discover from the deodar yield tables whether the volume per acre for any selected height in any one thinning grade can be converted to the correct volume at that height in any other thinning grade—by proportion of basal areas alone. From the yield tables (using some interpolation) it can be seen that a quality III stand having a height of 70 feet and subjected to a 'D' grade

thinning has a volume of 3,150 cubic feet and a basal area of 176 square feet per acre. A quality II stand of 70 feet mean height subjected to a 'C' grade thinning has a basal area of 215 square feet per acre. Therefore, by proportion of basal areas, the volume of the quality II stand should be $215/176 \times 3{,}150 = 3{,}850$ cubic feet. The yield tables state that the volume is 3,950 cubic feet. So the error of the calculation is only 100 cubic feet, or about $2\frac{1}{2}$ per cent.

Other similar comparisons give errors that are usually some 5 or 6 per cent., but may be as high as 12 per cent. (as far as tested). The large errors seem to occur when comparing stands very divergent in both quality class and treatment. For example, a stand of 70-foot trees quality IV under heavy 'E' thinnings has a volume of 2,500 cubic feet with a basal area of 131·8 square feet per acre. Using this information as a basis the *calculated* volume of a 70-foot quality I stand under a 'C' grade thinning with a basal area of 224·5 square feet is 4,258 cubic feet per acre. The yield tables give a volume of 3,875 cubic feet for such a quality I stand. So the error is +383 cubic feet or about +9 per cent.

From these and similar tests it may be assumed, therefore, that with deodar the volume of a stand is related to height irrespective of age, quality class, *and* treatment within 12 per cent. using proportion of basal areas as a corrective. But possibly it might be argued that it is the correction by proportion of basal areas that gives this degree of accuracy and not the fact that the relationship between volume and height remains true.

It is, therefore, necessary to compare two somewhat similar stands in both quality class and treatment but with differing *heights*. For example, consider a quality III stand 75 feet in mean height subjected to a 'C' grade thinning. Its basal area is found to be 233 square feet and its volume 4,850 cubic feet per acre. Consider then another quality III stand subjected to a 'D' grade thinning (the next heavier) but having a height of 65 feet. Its basal area is 167 square feet per acre. Therefore, by proportion of basal areas its calculated volume would be

$$\frac{167}{233} \times 4{,}850 = 3{,}475 \text{ cubic feet per acre.}$$

But for such a stand the yield tables give a volume of only 2,400 cubic feet. So the error here is +1,075 cubic feet or about +45 per cent. If, on the other hand, the heights of the two stands had each been 70 feet the error in the calculation of volume would have been only +8 cubic feet in 3,115 cubic feet or $+\frac{1}{4}$ per cent.

Other similar comparisons have shown that for stands of different heights the estimated volumes have inaccuracies of some 20 to 35 per cent. or more, compared with errors of about 5 per cent. when heights of stands are the same.

It may, perhaps, be concluded, therefore, that height is a good and accurate measure of volume (and other variables, such as basal area, &c.). Firstly (for British conifers at least), an accurate knowledge of the mean top-height enables the volume of fully stocked stands under a standard treatment to be calculated within an accuracy of some $99\frac{1}{2}$ per cent. of the yield table figures. Secondly (for deodar at least), if treatment has differed from the standard, then the volume can still be calculated from the height by proportion of the actual to 'normal' or standard

basal area, but the accuracy may be as low as 88 per cent. though probably only 95 per cent. if the treatment is not markedly different from the standard.

If these assumptions are sound (and it is admitted that a more detailed study is necessary) it seems that yield tables may attain a greater practical value. Some fifteen or more dominant, co-dominant, and one or two sub-dominant trees scattered over a compartment could be selected and measured as accurately as possible by instrument and the mean top-height calculated. The 'normal' basal area and volume per acre can then be read off from the top-height/volume curve or from the Modified Yield Table.

The next step would be to ascertain the actual basal area per acre of the stand—by total or suitable sample enumeration. Then the actual stand volume per acre =

$$\frac{\text{Actual basal area} \times \text{'Normal' volume per acre}}{\text{'Normal' basal area per acre}}$$

One objection to this proposal is that the average top-height must be accurately determined. Even if fair average top-height trees are selected for measurement an inaccuracy of 10 per cent. in estimation of the tree heights may give more than 10 per cent. error in volumes. For example, if the top-height of Sitka spruce is 80 feet, its volume per acre is 4,910 hoppus feet. But if its top-height is estimated wrongly to be 72 feet the volume would be taken to be 4,280 hoppus feet, i.e. about 13 per cent. less than the real volume. So, if height estimation is 10 per cent. wrong, giving a 13 per cent. error in volume, and if the basal area adjustment for stocking due to non-standard treatment causes a 5 per cent error, the total error may be 8 to 18 per cent. or some 20 per cent. wrong. But if the mean top-heights can be ascertained within 5 per cent. and if the thinning régime has been approximately the same as the standard employed by the Forestry Commission, errors of volume estimation may be expected to be within 10 per cent.

A further reference to the Modified Yield Table may be made. The figures for 'Thinning Yields' per acre have been ascertained by subtraction of the standing volume per acre from the total yield to date. Thus, against a height of 30 feet the Thinning Yield = Total Yield *minus* Standing Volume, while against a height of 35 feet the Thinning Yield = Total Yield *minus* Standing Volume and *minus* the 30-foot thinning yield. And so on. It will be noticed that the total yields to date for any given height tally with the appropriate yield table figures, but that the thinning yields do *not* tally. This is because of the appearance of the fourth dimension, time. The thinnings, according to this table, are repeated as soon as the stand increases 5 feet in height. This may be only 2 years for young quality I stands but 5 years for older quality IV stands. But during the time taken to reach a given height the thinning yield will be the same as the yield shown in the Forestry Commission Tables. Thus, the total thinning yield in the Modified Table for a stand 110 feet high adds up to 5,880 hoppus feet. The total thinning yield from quality I Sitka spruce 50 years old (110 feet high) is also 5,880 hoppus feet. Similarly for any other height in any quality class. In fact, silviculturally though impracticably, the ideal interval between thinnings would be on a cycle based on the time taken by the stand to increase by some fixed mean height.

but the coefficient of log h is not significant, and the expression gives no greater accuracy than a simple regression on log d.

Analysis of the variation within stands showed that in the comparison of individual plants within a stand the partial coefficients of log d and log h were both significant. The average values of these coefficients were 2·10 and 0·64, but they varied considerably from stand to stand.

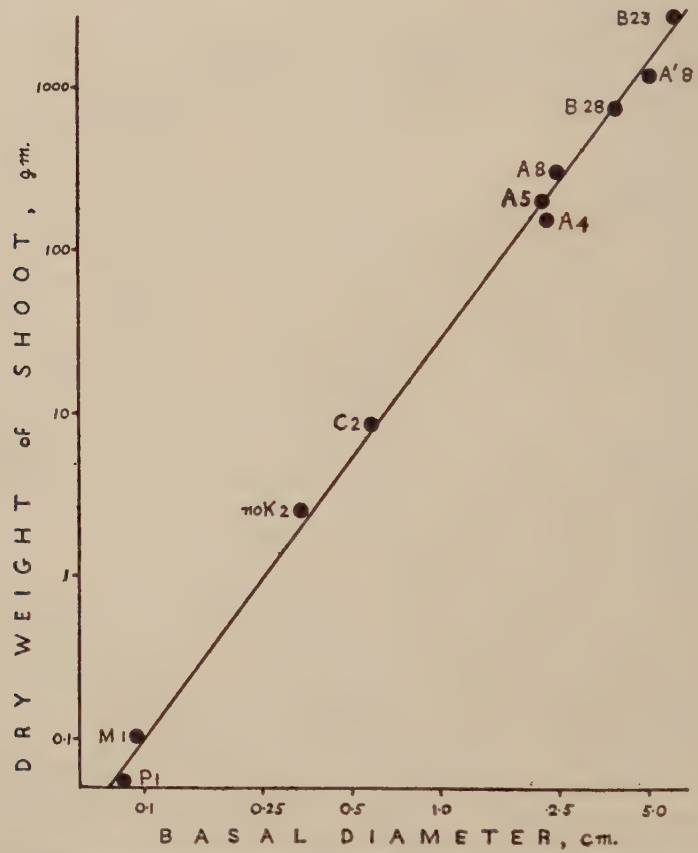


Fig. 5. The relation between basal diameter and dry weight of the shoot in Sitka spruce. Averages of twenty trees.

GENERAL SUMMARY ON SCOTS PINE AND SITKA SPRUCE

In both the species studied it has been found that for the comparison of young stands, the mean dry weight of the shoot (stem and leaves) can be calculated from the diameters by the following formulae:

$$\text{Scots pine} \quad \log W = 1{\cdot}38 + 2{\cdot}41 \log d$$
$$\text{Sitka spruce} \quad \log W = 1{\cdot}45 + 2{\cdot}43 \log d,$$

where W = mean dry weight of shoot, grammes,
and d $= \sqrt{1/n \cdot \Sigma d^2}$.

If samples of thirty to fifty plants are taken, the standard errors attached to these estimates are equivalent for pine to about ± 13 per cent. and for spruce about ± 18 per cent. of the mean weight of any sample.

The errors attached to estimates of weight similarly derived from height measurements are for pine -58 per cent. to $+139$ per cent. and for spruce -47 per cent. to $+89$ per cent. No appreciable or statistically significant gain in accuracy has been obtained by using expressions which combine diameter and height measurements, rather than those based on diameter alone.

The above expressions do not hold for the comparison of individual trees within a stand. For Scots pine the weights of single trees within a stand are on average proportional to $d^{2 \cdot 11}$ and for Sitka spruce to $d^{2 \cdot 11} \times h^{0 \cdot 64}$. These relationships, however, vary from stand to stand.

ACKNOWLEDGEMENTS

In addition to various members of H.M. Forestry Commission who have supplied me with plants, I should particularly like to thank Mr. M. V. Edwards for his encouragement to me to prepare this work for publication. I am grateful also to Mr. F. Jones for his assistance in dealing with the samples.

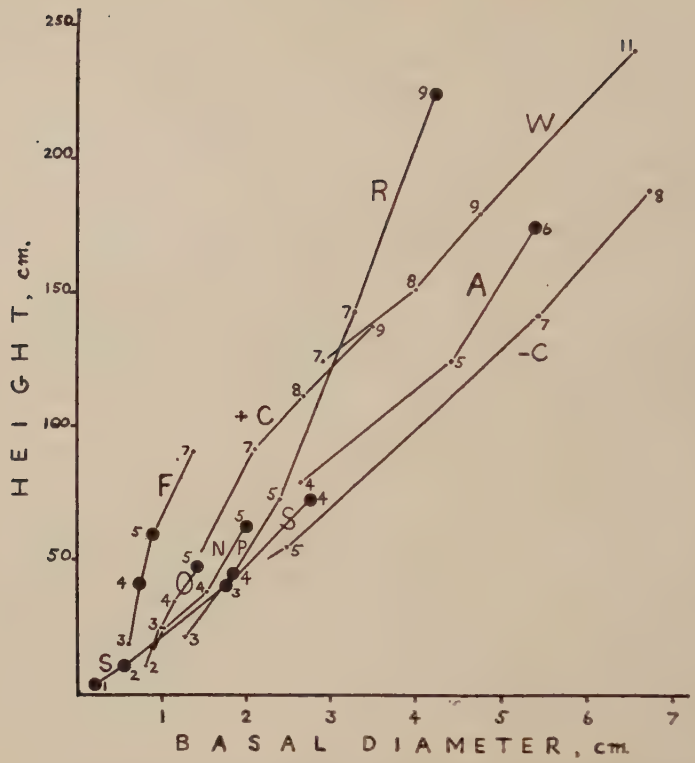


FIG. 1. Growth in height and basal diameter of a number of young stands of Scots pine. Figures against the lines are years from germination. Dark circles are samples whose dry weight was also determined. For key to labels see Table I.

TABLE I. *Conditions of growth of the stands shown in Fig. 1.*

Label	*Plants*	*Soil conditions*	*Spacing*
S	Transplants	Silty loam, clean cultivated	12 in. × 18 in.
A	,,	Sandy loam, clean cultivated	24 in., single row
W	,,	Wet heath, *Molinia* dominated	5 ft. × 5 ft.
O	,,	In pots for third to fifth years, no fertilizer	15 in. × 15 in., double row
NP	,,	In pots as above, additional nitrogen and phosphorus	,,
F	Natural regeneration	In furrows, double furrow ploughing, podzolized sand	Approx. 1 plant per 11 sq. ft.
R	,,	On ridges, same ploughed land as F	Approx. 1 plant per 3 sq. ft.
+C	,,	Podzolized sand, not ploughed, *Calluna* dominated	Approx. 1 plant per 30 sq. ft.
—C	,,	As +C, but *Calluna* removed	,,

were made at the hypocotyl, which in the age range studied is usually easily recognizable.

In Fig. 1 are presented data showing the increase with age of height and basal diameter in a number of stands of young trees growing in different conditions. Each line is the average of about thirty trees. A key to the labels in the figure is given in Table I. The spacing of the trees in some of the stands may seem very close, but these were plants grown only for a limited number of years, during which time their spacing appeared to be adequate in relation to their height.

Fig. 1 shows that height and diameter increase are not equivalent measures of growth, and that the discrepancy between them is especially marked in the first few years. For instance stands of mean height 60 cm. may have mean diameters ranging from 1 to nearly 3 cm. In an extreme comparison, viz. between stands R and F, height growth for the first 5 years was almost identical, but radial growth very different. This could hardly be ascribed to differences in spacing, since the stand R with the more rapid radial growth was the more densely crowded of the two. Although the high density of stand R appeared to have had little effect on radial growth in the first few years, in later years it resulted in low basal diameters in relation to height. The stands W, −C, and +C were all similarly spaced at a normal density for plantations of Scots pine. Comparing −C with either +C or W, it will be seen that after an initial divergence of the diameters, their difference at a given height remained constant at about 1·7 cm. At a height of 100 cm., −C had a diameter about 70 per cent. greater than +C, but with increasing height the absolute diameter difference of 1·7 cm. became relatively less important and it seems probable that when these stands reached the thinning stage the relative difference in diameters for a given height would be so small that height and diameter would be approximately equivalent measures of growth.

The points in Fig. 1 marked by circles represent samples which after measurement were oven-dried and weighed, and these same samples have been used in Figs. 2 and 3 to show the relation between mean dry weight of the above-ground parts on the one hand, and mean height or mean basal diameter on the other. If both the weights and the linear measures are plotted on a logarithmic scale, the relationships are linear, but it will be seen that height is much inferior to diameter as an index of weight. The close relation between diameter and weight is remarkable in that (*a*) it holds over a range in which the weight of the largest plants is several thousand times that of the smallest, (*b*) it holds for plants growing in markedly contrasted conditions of nutrition and spacing, and (*c*) the plants were of two different seed origins. These points will be elaborated a little.

The smallest plants were 1-year seedlings, whose organization is very different from that of older trees. Nevertheless they fit exactly on to the line. Of the largest trees, R9 were dense natural regeneration whose height was approximately four times their distance apart. They could therefore be said to have closed canopy, but this had not produced any appreciable deviation from the linear relationship and it seems safe to assume that the line may be extrapolated at least for a few years into the thicket stage.

There was no doubt a large difference between the soil fertility of stands S, R,

and F, since at 4 years their dry weights per plant were 278, 93, and 12 grammes respectively. A comparison of plants with a clearly defined difference in nutrition is provided by 'stands' O and NP which were grown through their third, fourth, and fifth years in pots, respectively without fertilizer and with additional nitrogen and phosphorus. At the end of this period the fertilized plants were about two and a half times the weight of the unfertilized. Neither the severe restriction

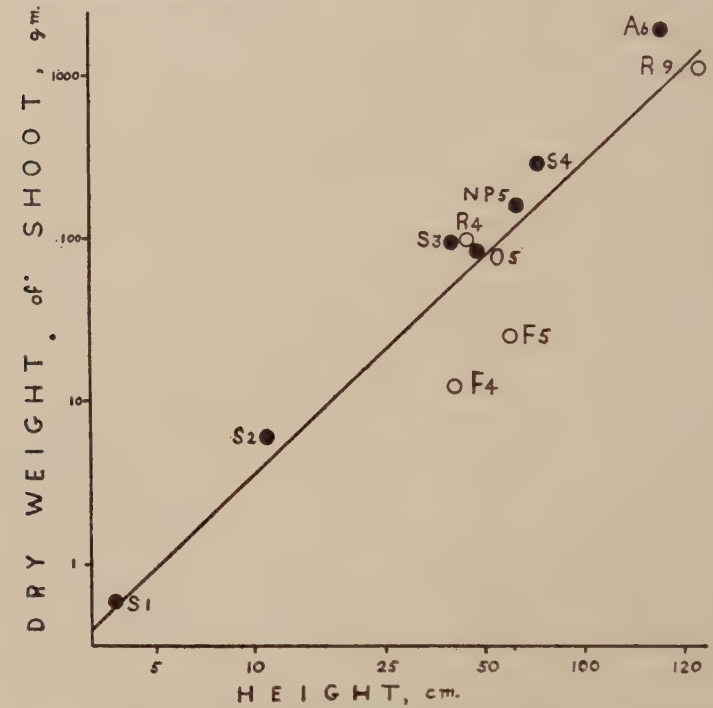


FIG. 2. The relation between height and dry weight of the shoot in Scots pine. Averages of about thirty trees.

of the roots in pots nor the differences in nutrition have altered the relation between weight and diameter.

To distinguish the different seed origins, open circles have been used to represent trees naturally regenerated from a small group of Scots pine at Bramshill, while the closed circles represent trees derived from seed supplied by Mr. R. F. Wood of the Forestry Commission (Figs. 2 and 3).

The relation between the mean weights and mean diameters of the ten samples which are shown in Fig. 3, was found to be

$$\log W = 1{\cdot}42 + 2{\cdot}41 \log d,$$

which may also be expressed $W = 26{\cdot}2d^{2{\cdot}41}$,

where W = mean dry weight per shoot, grammes,

and d = mean hypocotyl diameter, centimetres.

The standard error of the difference between the observed and calculated values of log weight is $\pm 0{\cdot}07466$. The antilog of this is approximately $\times 1/1{\cdot}19$ or $\times 1{\cdot}19$, which is equivalent to -16 per cent. or $+19$ per cent. The errors of other regressions which have been calculated will be expressed in the same way.

The corresponding regression relating mean weight to mean height (h) in centimetres is

$$\log W = -1{\cdot}34+1{\cdot}89 \log h,$$

and the standard error of the difference between observed and calculated values of log W is then equivalent to -58 per cent. or $+139$ per cent. of the untransformed weights.

Since weight and diameter are not linearly related, it is not altogether satisfactory to derive their relation from their arithmetic means in various stands, especially when there is considerable size variation within a stand. It would be preferable to calculate the regression from the logarithms of the weights and diameters of individual plants, or from the stand means of these logarithms. However, many of the data were obtained in a way which did not distinguish the dry weights of individual plants, although the diameters were separately recorded. Now weight is in approximately linear relation to the square of diameter and so the regression can be more correctly calculated from the arithmetic means per stand of the weights (the only figures available), and the mean diameters calculated by the formula $\bar{d} = \sqrt{1/n \cdot \Sigma d^2}$. The regression so obtained was

$$\log W = 1{\cdot}38+2{\cdot}41 \log \bar{d},$$

or

$$W = 24{\cdot}0\, \bar{d}^{2{\cdot}41}.$$

This does not differ much from the expression given above, but the standard error of the difference between observed and calculated values of log weight has been reduced to $\pm 0{\cdot}05734$ which is equivalent to -12 per cent. or $+14$ per cent. of the mean weight of a stand.

In five stands where individual weights had been separately recorded, it was possible to calculate the relation between weight, diameter, and height for individual plants within a stand. Here again it was found that after taking logarithms, weight was much more closely related to diameter than to height. The regression coefficients, however, varied significantly from stand to stand, the coefficient of log diameter taking values from 1·75 to 2·25, with a mean of 2·15; and of log height, values from 0·70 to 2·10, with a mean of 1·45.

From the data of these five stands it was found that the calculation of mean weight from mean diameter of thirty trees from one stand is subject to a sampling error of about ± 2 per cent. It is evident, therefore, that sampling errors do not contribute much to the error of -12 per cent. to $+14$ per cent. attached to the comparison of samples drawn from different stands.

The possibility was also investigated that a better estimate of weight might be obtained from an expression which combined diameter and height measurements, and the following multiple regression of log weight on log diameter and log height was calculated for comparisons between stands:

$$\log W = 1{\cdot}19+2{\cdot}26 \log d+0{\cdot}37 \log h.$$

However, it was found that there was no significant improvement in fit through using this multiple regression instead of a simple regression on log diameter alone; and this was true of comparisons both within and between stands.

DISCUSSION OF RESULTS FOR SCOTS PINE

Some explanations may be suggested for the discrepancy between height and diameter as measures of growth. In the first place the relation between them is altered by density. It is well known that within fairly wide limits of thinning intensity the mean height of a stand remains constant while the mean diameter is

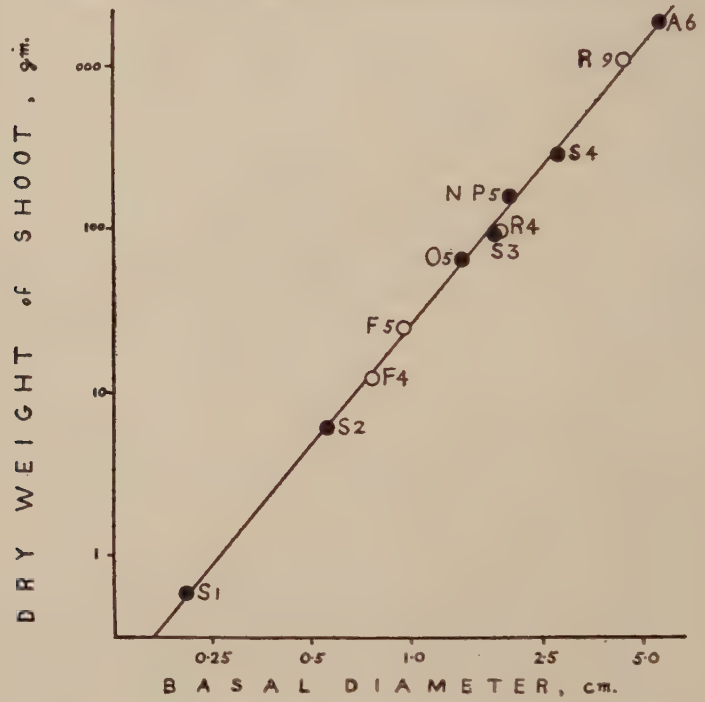


FIG. 3. The relation between basal diameter and dry weight of the shoot in Scots pine. Averages of about thirty trees.

inversely related to the density. Hence there may be a closer relation between height and total basal area than between height and mean basal area. In the young stands illustrated in Fig. 1, one stand (R) shows restricted radial growth relative to height growth which could be attributed to close spacing, but in other cases there was a difference between the mean diameters of stands of the same height which could not be explained by differences in density.

In the second place there is a lag between radial growth and height growth and between their response to changing conditions, for radial growth can be affected by a treatment in the year of its application, whereas the main response of height growth is in the following year. Radial growth appears to be an expression of

current assimilation while height growth is largely determined by conditions affecting development in the terminal bud in the year preceding its extension. One should therefore look for a correspondence between radial growth in one year and height growth in the following, and if the data of Fig. 1 are recast in such a way that each diameter is plotted against the following year's height, the range of diameters at a given height is much reduced.

But when allowance has been made both for the lag between radial growth and height growth, and for variations in density between different stands, there still remains a considerable unexplained variation in the relation between the mean heights and diameters of stands, and it has not been found possible to correct them in any way which will make them equivalent measures of the growth in weight either of stands or of single trees. In these circumstances it is concluded that height is far inferior to diameter as a measure of weight.

Finally it must be emphasized that these conclusions relate only to young trees in the stage of growth before the formation of canopy. With increasing age there appears to develop a close correspondence between height and girth in stands of similar stocking, irrespective of the quality;[1] and whatever their relation to dry weight may be, they are then approximately equivalent measures of growth.

PART II. SITKA SPRUCE (*PICEA SITCHENSIS* BONG. [CARR.])

The data for young plants of Scots pine presented in the first part of this paper demonstrated that there is a close relationship between the dry weight of the shoot (stem and leaves) and the basal diameter, a relationship which seemed to be unaffected by age, at least to the thicket stage of growth, or environmental conditions. It seemed desirable to know whether a similar relationship held for other trees, and Sitka spruce was chosen as a species of economic importance and a common subject of forestry experiments, as well as for its generic difference from Scots pine.

Plants were supplied from the Alice Holt pathology nursery by Mr. J. S. Murray, from Sugar Hill nursery, Wareham, by Mr. J. R. Aldhous, and from Bramshill Forest by permission of the Conservator, Mr. R. H. Smith.

A standardized procedure was followed in dealing with the plants. Samples consisted of twenty plants, and for each plant there was obtained the fresh weight of the shoot, the height, and the basal diameter. To determine the relation between fresh weight and dry weight, from four to eight plants from each sample were oven-dried and weighed. Within a sample the dry weight/fresh weight ratio was very similar from plant to plant and could be accurately determined by drying a few plants; the dry weights of the remaining plants were then calculated from their fresh weights. As in the case of Scots pine, roots were excluded from the weighing, since the roots of the larger plants could not be completely recovered from the soil. The distinction between root and shoot is less clear in spruces since if they are planted deep, roots arise from the buried part of the stem, a

[1] Hummel, F. C., and Christie, J. (1953). *Revised Yield Tables for Conifers in Great Britain.* For. Comm., For. Res. No. 24.

response which I have not observed in Scots pine. Root and shoot were arbitrarily separated immediately above the uppermost strong lateral root and little difficulty was experienced in applying this criterion. Occasionally there were a few fibrous roots to be seen a little above this level, but they were neglected. Heights were measured from this point of separation, and basal diameters 1 cm. above it. The mean of two diameters at right angles was recorded. The whole of the work was carried out in November and December 1954.

In Table II are given particulars of the sampled stands. The spacings of the Alice Holt plants were those found at the time of sampling; they had been

TABLE II. *The sampled stands of Sitka spruce*

Label and no. of years from germination*	*Locality*	*Conditions*	*Spacing*
P1	Silwood Park, Berks.	Poor quality seed-beds	1 in. × 1 in.
M1	" "	Moderate " " "	"
C2	Wareham	Hop waste compost	Transplant lines
noK2	"	Potassium deficient	" "
A4	Alice Holt	Fertile clay loam	2 ft. 6 in. × 1 ft. 6 in.
A5	" "	" "	2 ft. × 1 ft.
A8	" "	" "	1 ft. 6 in. × 3 ft.
A'8	" "	" "	2 ft. 6 in. × 3 ft.
B28	Bramshill	Wet heath, severe check	5 ft. × 5 ft incomplete
B23	"	Wet heath, partial check	" "

* See Figs. 4 and 5.

progressively thinned since planting. The ten stands covered a wide range of age, and of environmental conditions, in respect both of nutrition and density of planting. At opposite extremes of growth quality were stand B28, about 3 feet high at 28 years after planting, and stand A'8, nearly 8 feet high at 6 years after planting. The plants of stands A4, B28, and B23 were all separated by distances at least equal to their height, while A8 and A'8 were two to three times as high as their distance apart.

In Figs. 4 and 5 are shown the relationships between the mean dry weights of the stands on the one hand, and their mean heights and diameters respectively on the other. It may be seen that, as in Scots pine, the relations are linear when the data are plotted on logarithmic scales, and that dry weight is more closely related to basal diameter than to height.

The regression of weight on diameter is

$$\log W = 1{\cdot}45 + 2{\cdot}43 \log \bar{d}$$

or

$$W = 28{\cdot}3\, \bar{d}^{2{\cdot}43},$$

where W is the mean weight of the stand, grammes, and $\bar{d}$ is the mean diameter, centimetres, calculated by the formula $\bar{d} = \sqrt{1/n\Sigma \cdot d^2}$; this gives a somewhat closer fit than a simple arithmetic mean of the diameters.

The numerical similarity between this regression and the corresponding one for Scots pine is striking, although the accuracy is lower in the case of Sitka spruce. The standard error of the difference between observed and calculated values of log weight is $\pm 0{\cdot}0802$ which is equivalent to about -17 per cent. or $+20$ per cent. on the untransformed scale. Some allowance might be made for the fact

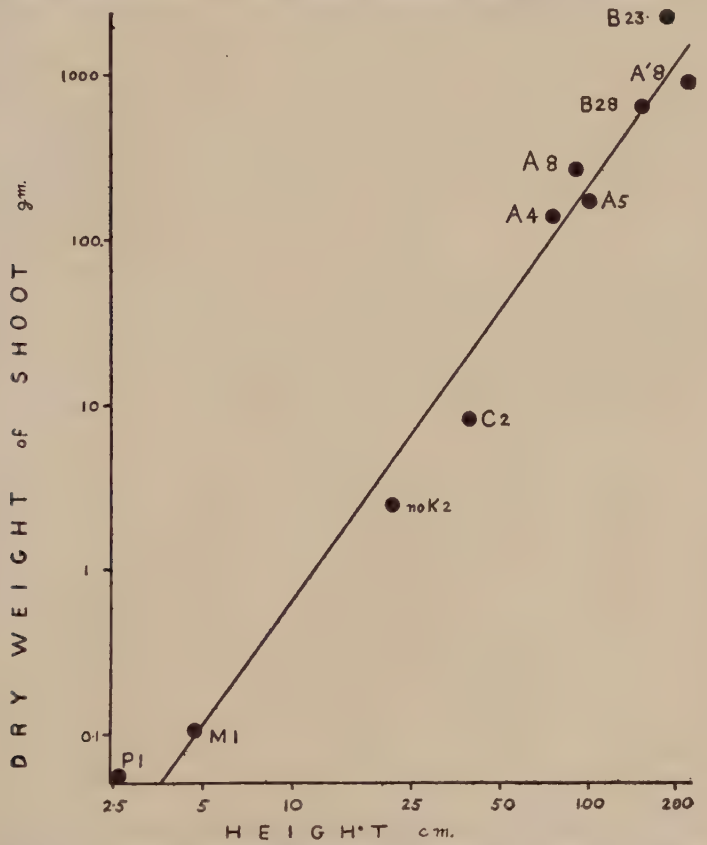


FIG. 4. The relation between height and dry weight of the shoot in Sitka spruce. Averages of twenty trees.

that smaller samples were taken in the case of Sitka spruce, but calculation of the variation within stands shows that sampling errors contribute less than ± 2 per cent. to the total error between stands given above. The accuracy is, however, far higher than can be obtained by using height to estimate weight. The regression in this case is

$$\log W = -2{\cdot}76+2{\cdot}55\ h,$$

where h is the mean height in centimetres, and the standard error of this estimate of weight is equivalent to -47 per cent. or $+89$ per cent.

Multiple regressions between and within stands, relating dry weight to a combination of diameter and height, were also calculated. The expression relating stand means is

$$\log W = 0{\cdot}60+2{\cdot}29 \log d+0{\cdot}15 \log h,$$

but the coefficient of log h is not significant, and the expression gives no greater accuracy than a simple regression on log d.

Analysis of the variation within stands showed that in the comparison of individual plants within a stand the partial coefficients of log d and log h were both significant. The average values of these coefficients were 2·10 and 0·64, but they varied considerably from stand to stand.

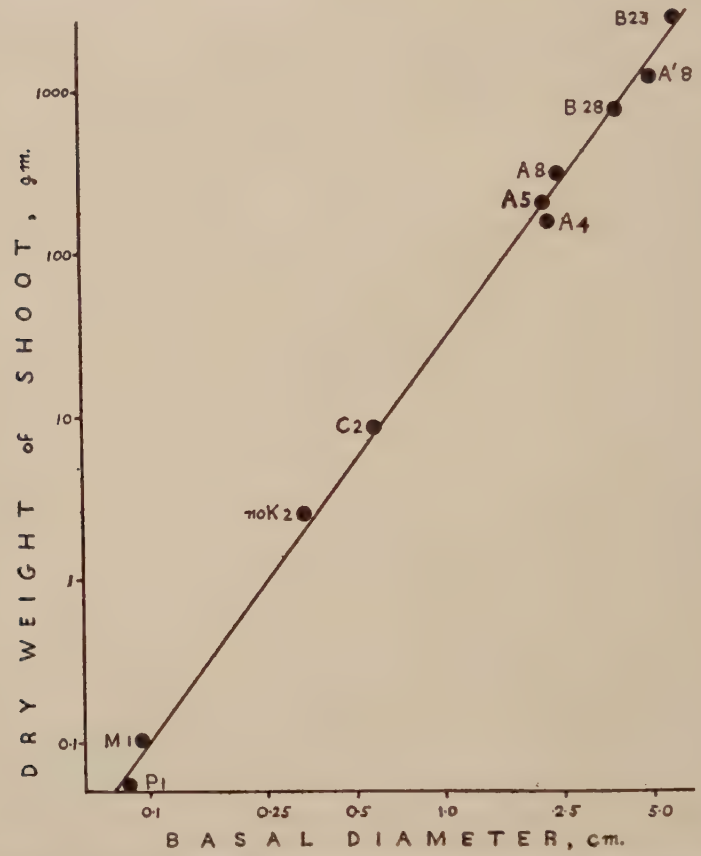


FIG. 5. The relation between basal diameter and dry weight of the shoot in Sitka spruce. Averages of twenty trees.

GENERAL SUMMARY ON SCOTS PINE AND SITKA SPRUCE

In both the species studied it has been found that for the comparison of young stands, the mean dry weight of the shoot (stem and leaves) can be calculated from the diameters by the following formulae:

$$\text{Scots pine} \quad \log W = 1{\cdot}38 + 2{\cdot}41 \log d$$
$$\text{Sitka spruce} \quad \log W = 1{\cdot}45 + 2{\cdot}43 \log d,$$

where W = mean dry weight of shoot, grammes,
and d $= \sqrt{1/n \cdot \Sigma d^2}$.

If samples of thirty to fifty plants are taken, the standard errors attached to these estimates are equivalent for pine to about ± 13 per cent. and for spruce about ± 18 per cent. of the mean weight of any sample.

The errors attached to estimates of weight similarly derived from height measurements are for pine -58 per cent. to $+139$ per cent. and for spruce -47 per cent. to $+89$ per cent. No appreciable or statistically significant gain in accuracy has been obtained by using expressions which combine diameter and height measurements, rather than those based on diameter alone.

The above expressions do not hold for the comparison of individual trees within a stand. For Scots pine the weights of single trees within a stand are on average proportional to $d^{2.11}$ and for Sitka spruce to $d^{2.11} \times h^{0.64}$. These relationships, however, vary from stand to stand.

ACKNOWLEDGEMENTS

In addition to various members of H.M. Forestry Commission who have supplied me with plants, I should particularly like to thank Mr. M. V. Edwards for his encouragement to me to prepare this work for publication. I am grateful also to Mr. F. Jones for his assistance in dealing with the samples.

THE EFFECT OF RAINFALL ON THE LATE WOOD OF SCOTS PINE AND OTHER CONIFERS IN EAST ANGLIA

By E. H. M. HARRIS

SUMMARY

In Scots pine (*Pinus silvestris* L.) near Oxford, early wood was found to start growing at about the beginning of April, late wood at about the beginning of July, and growth ceases at about the end of August. Five late wood types were distinguished in pine growing under the 'continental' climatic conditions of East Anglia. These types appear to be related to rainfall distribution. The sharpness of the inner edge of the late wood depends upon the availability of water at the end of early wood formation, a dry spell causing a sharp distinction. Wet conditions in the middle of late wood formation may cause a zone of less dense tissue, but this is rare.

INTRODUCTION

A PAPER published recently in this Journal by Dobbs (4), proposing a pattern of false rings or 'lines' in European larch (*Larix decidua* Mill.) in south-west England and relating them to dry-wet contrasts during the growing season, seemed worth following up elsewhere on another species. For this the continental type climate of East Anglia was chosen to contrast with that of the south-west and the abundance of Scots pine (*Pinus silvestris* L.) thinnings on Thetford Chase offered ample material for the investigation.

The work fell into two parts. Firstly a study of the course of growth during the year in Scots pine undertaken so that characters within the ring might be related to particular periods of the growing season. Secondly an analysis of characteristic rings, based on various late wood types, to show their relation to weather conditions.

MATERIAL AND METHODS

In order to study the course of growth, a technique first used by Brown (1), and subsequently by Chalk (2) and others, was employed. Blocks containing the whole of the current year's ring were extracted from two trees at fortnightly intervals during the spring of 1953. These were obtained in Bagley Wood, near Oxford, as it was not possible to travel regularly to Thetford. The series was extended with blocks taken from the same trees during the summer of 1945 and kindly made available by Dr. E. W. Jones.

The second part of the work was carried out on disks, about 2 inches thick, from dominant and co-dominant trees about 25 years old. Material was collected from ninety-one trees on nineteen sites on Thetford Chase and from two sites in Swaffham Forest. In order to obtain the greatest number of rings and to avoid wastage of thinnings, the disks were at first cut from the butts. It was found, however, that characteristic rings are both more evident and more consistent in sections taken higher. The best position appeared to be between 4 and 8 feet from

ground-level but this point deserves further investigation. In future work material could be obtained where the pole is cross-cut for pit-props.

Some characteristic rings were recognizable in the freshly cut disks, but for detailed investigation it was necessary to clean the surface thoroughly by planing and careful glasspapering. The surface was then treated with beeswax. This brings out the contrast between early and late wood in the same way as flooding with water but the effect is permanent. The surface remains clean, it is protected from fungus infection, and cracking of the disks is delayed for some weeks, whereas finished sections left unwaxed for a few days crack severely.

Meteorological figures from the Forestry Commission station at Lynford Hall, kindly made available by Mr. P. C. Gough, were used. These were supplemented by descriptive day-to-day weather records for Norwich given by Willis (7).

COURSE OF GROWTH DURING THE SEASON

Transverse sections, from the blocks already described, were examined under the microscope to determine the approximate date of the beginning of growth, the beginning of late wood formation, and the end of growth. The beginning of growth was studied in the 1953 material; growth had begun in a dominant tree by the last week in March and in a suppressed tree by the second week in April. The beginning of late wood formation was covered by the 1945 material; about six layers of late wood cells were visible in the second week of July in both trees and both trees were still growing on 15th August but had finished by 17th September.

DISTINCTIVE TYPES OF LATE WOOD

Late wood varies macroscopically in colour, in width, and in the percentage of the annual ring it occupies. Microscopically there was variation in thickness of the cell walls and the size of the cell lumina in different parts of the late wood and, as would be expected, particularly thick-walled cells produce dark-coloured late wood and thin-walled cells light-coloured wood.

The inner rings do not show characteristics that are constant throughout the circumference and, as little of the material available at Thetford is more than 25 years old, only the outer twenty rings were studied. Five different types of ring showing variation in late wood occur and these can be related to the weather conditions prevailing during their formation, particularly to rainfall distribution (see Fig. 1 and also Figs. 2*a* and 2*b* in Plate VI). These types are described below.

Type 1. Outer Zone of Late Wood composed of Cells with Large Lumina

This type occurred in 1945 and 1952 and can be attributed to the high rainfall experienced in both years during August when the outer late wood cells were formed.

Type 2. Late Wood composed of Three Zones: Two Dark-coloured Bands separated by Lighter Wood

This type occured in 1937 and 1949. The latter year had a cool summer and low rainfall whilst the former had a warm summer and high rainfall. During the

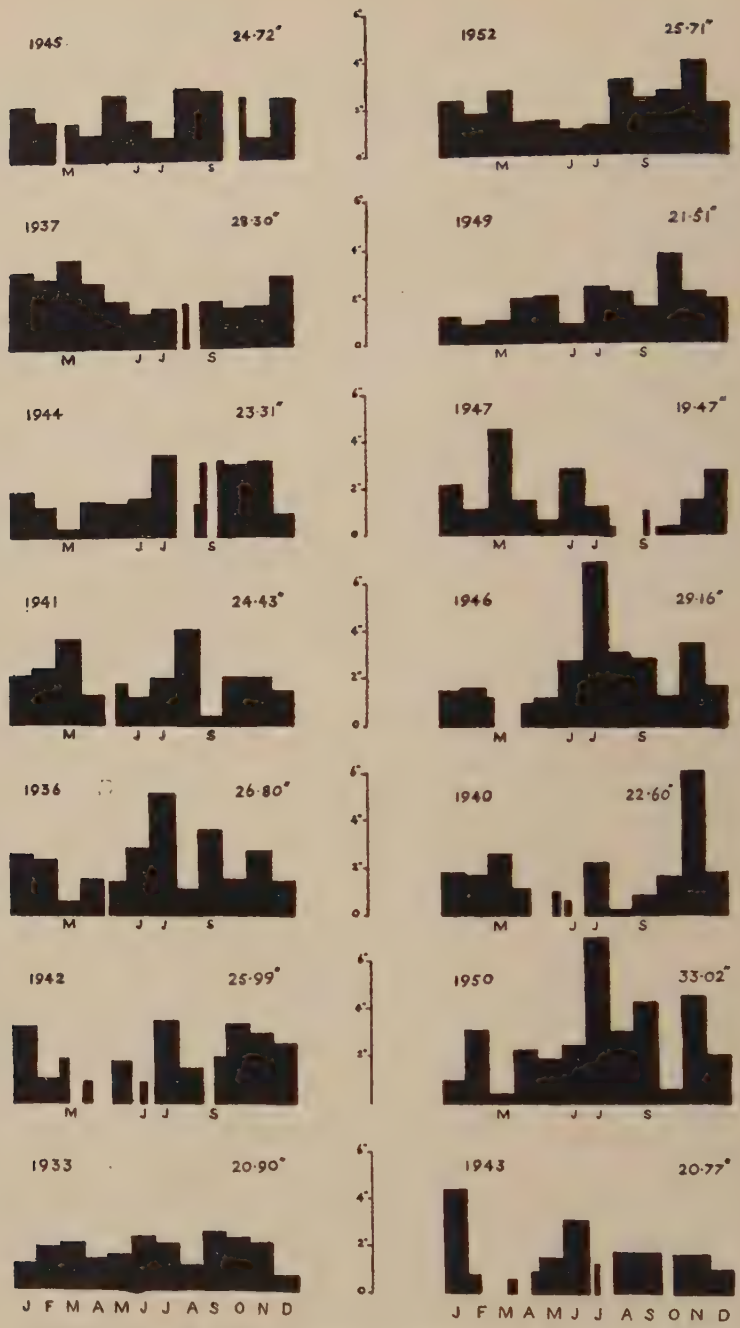


FIG. 1. Distribution of rainfall month by month for years showing characteristic growth rings.

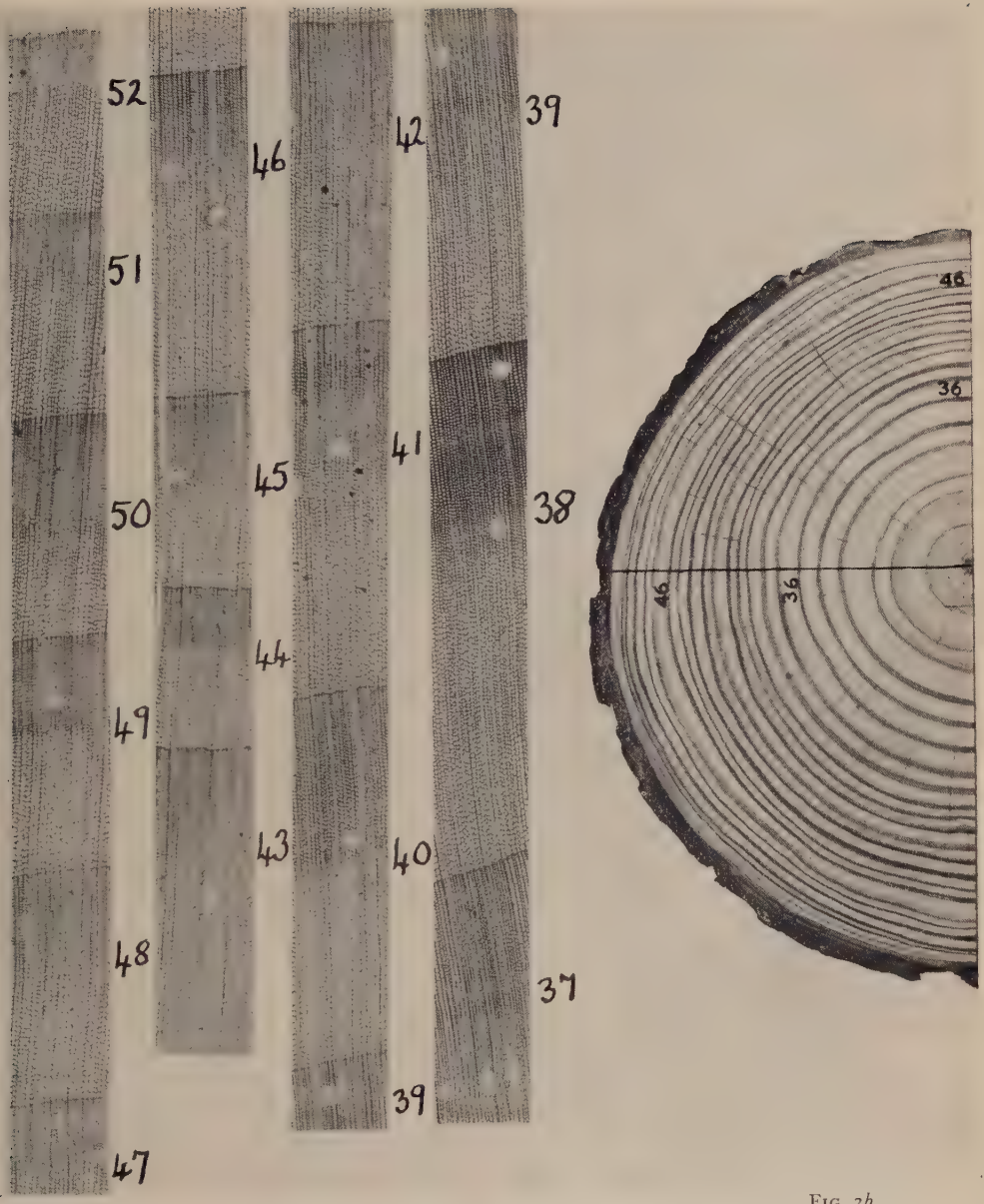


FIG. 2*a*

FIG. 2*b*

FIG. 2*a*. Photomicrograph of rings for 1937 to 1952 × 16.
FIG. 2*b*. Half-disk cut at 6 feet from ground-level from a dominant tree.

PLATE VI

formation of the late wood, dry conditions prevailed in both years but with an intervening short wet spell, causing the formation of the less dense band.

Type 3. A Narrow, Dark-coloured Band of Late Wood

This type occurred in 1944 and 1947. The weather records for these 2 years are strikingly similar. Both growing seasons were short and dry and thick-walled late wood cells were formed for a short period only.

Type 4. A Broad, Light-coloured Band of Late Wood

This type occurred in 1941 and 1946 and contrasts with Type 3. Average summer temperatures and total rainfall are dissimilar for the 2 years. In both, however, rainfall was high during the period of late wood formation resulting in a wide band of relatively thin-walled cells with large lumina.

Type 5. Early Wood merging gradually into Late Wood

This type is the most common and occurred in 1936, 1940, 1942, and 1950. These years were characterized by high July rainfall. It is suggested that abundance of moisture at the beginning of late wood formation favours this gradual change in cell type. By contrast a sharp inner edge to the late wood is found in Type 3, which occurred when low July rainfall was recorded.

In addition to these five types it is significant that the zone of early wood in the ring of 1933 is exceptionally wide. Although the total rainfall during that year was low, this was evenly spread over the growing season, which was recorded by Willis (7) as a particularly long one, beginning early and ending late. It seems probable that early wood started forming earlier than usual and that the change to late wood formation was delayed. A long, warm season with the same total rainfall occurred in 1943 but the proportion of early wood formed was not high; this was probably because of checks to growth provided by three dry spells during the season.

A positive relation between ring formation and weather occurs in 70 per cent. of the years considered. In the remainder neither the rings nor the weather records show any marked characteristics and so no relationship can be established.

DISTINCTIVE LATE WOOD IN OTHER SPECIES

Corsican Pine

Nine disks of Corsican pine (*Pinus nigra* Arnold var. *calabrica*) were collected from three sites on Thetford Chase. The same series of late wood types occurs but is less marked than in Scots pine. This suggests a less sensitive reaction by the species to the weather conditions in East Anglia.

European Larch

Ten disks of European larch were collected from Swaffham Forest. The rings characteristic of Scots pine cannot be recognized in them, with the exception of a double ring in 1949 which may be comparable with Type 2 found in the same

year. Dobbs's (3) pattern of 'lines' for European larch was not present in the 16 comparable years covered by the Thetford disks. The material, however, leaves little doubt that a local pattern could be established which would throw further light on the hypothesis of dry-wet contrast proposed by Dobbs (6).

Douglas Fir

Ten disks of Douglas fir (*Pseudotsuga taxifolia* Britt.) from Thetford Chase were examined. The late wood was found to be similar to that of larch but with less suggestion of a pattern of 'lines', and the Scots pine late wood types do not occur.

CONCLUSIONS

From these investigations the following conclusions may be drawn. Ring characteristics in pine differ from those observed by Dobbs in larch and consist of a series of late wood types rather than a pattern of 'lines'. The importance of the distribution of rainfall during the growing season stressed by Dobbs was confirmed, but the effect in pine was rather different. Dobbs's 'single line' is similar to Type 3 but this is uncommon in the pine and Dobbs's multiple lines do not occur at all.

The Thetford larch did show a 'line' pattern but quite a different one from that obtained by Dobbs (3). This confirms his suggestion (5) that these patterns may be of only local extent.

The effect of adverse weather conditions may be different at different stages in the growing season. It seems probable that the reaction of different species to these weather conditions may be affected both by inherent tolerance of dry conditions and by the date at which late wood is formed.

ACKNOWLEDGEMENTS

Grateful acknowledgement is made to Professor H. G. Champion for permission to carry out the work at the Imperial Forestry Institute and to Dr. L. Chalk for assistance with the preparation of this paper; also to Messrs. G. W. Backhouse and S. W. Rogers (Forestry Commission) for allowing the collection of material at Thetford Chase.

LITERATURE REFERENCES

(1) Brown, H. P. (1912): 'Growth Studies in Forest Trees.' *Bot. Gaz.* liv. 386–402.
(2) Chalk, L. (1930): 'The Formation of Spring and Summer Wood in Ash and Douglas Fir.' *Oxon. For. Mem.* 10.
(3) Dobbs, C. G. (1942): 'A False-Ring Pattern in Larch.' *Nature*, cl. 377.
(4) —— (1951): 'A Study of Growth Rings in Trees, Part I. Review and Discussion of Recent Work.' *Forestry*, xxiv. 1, 22–35.
(5) —— (1952): 'Part II. A Ring Pattern in European Larch.' *Forestry*, xxv. 2, 104–25.
(6) —— (1953): 'Part III. The Relation of "Lines" to Summer Weather.' *Forestry*, xxvi. 2, 97–110.
(7) Willis, J. H. (1944): '*Weatherwise; England's Weather Through the Past Thirty Years.*' Allen & Unwin, London.

A COMPARISON OF LIGHT IN DIFFERENT WOODLANDS

By J. D. OVINGTON and H. A. I. MADGWICK

(*The Nature Conservancy, Merlewood Research Station, Grange-over-Sands*)

SUMMARY

At Bedgebury, a comparison has been made between the light intensities in fifteen forest plots and five open areas during the wide range of light conditions found in spring and summer. Light distribution under a tree canopy is extremely variable so that it was essential to make a large number of random observations within each plot. The percentage of light penetrating the diverse canopies has been found to differ considerably both from plot to plot and from season to season. Some of the factors which determine the amount of light passing through the canopy and their effects on the ground flora and natural regeneration are discussed.

INTRODUCTION

THE Forestry Commission have established at Bedgebury, in Kent, numerous even-aged plantations of different tree species within an area of 40 acres (7). Inter-related studies of the environments in some of these plots are being made, and in *Forestry* (4) an account was given of the rainfall reaching the various forest floors together with a general silvicultural description of the plantations. The light climates under the diverse canopies of the tree stands are not constant and in the present paper the results are presented of a corresponding comparative study of light intensity.

METHODS

Throughout sunny periods the light pattern over the ground in woodlands is very irregular with numerous bright sunflecks and deep shadows, the positions of which change during the day. Because of this it was felt inadvisable to measure light intensity at any one fixed point and the field procedure and apparatus were so designed as to give a number of readings at random positions within the woodland and, at almost the same time, to take the same number of readings in the open.

For light measurements in the plantations two photoelectric cells A_1 and A_2 were fitted to a readily movable platform at one metre above ground-level, the cells A_1 and A_2 giving accurate readings at high and low light intensities respectively. By means of a two-way switch either cell could be used according to the intensity of the light encountered, so that it was possible to cover accurately the wide range of light conditions found in woodlands. In the open a third cell B was also placed at one metre above the ground on a carefully levelled platform away from any trees. Many of the forest plots are adjacent to one another so that five open area controls were sufficient for the fifteen woodland plots examined. The cells in the woodland and the open were connected by 200-foot flexible cables to a light meter fitted with a two-way switch so that either the A or B cell could be put quickly into circuit as required. Incorporated in the meter was a series of resistances by means of which it was possible for each photoelectric cell to cover several light ranges, each using the whole galvanometer scale.

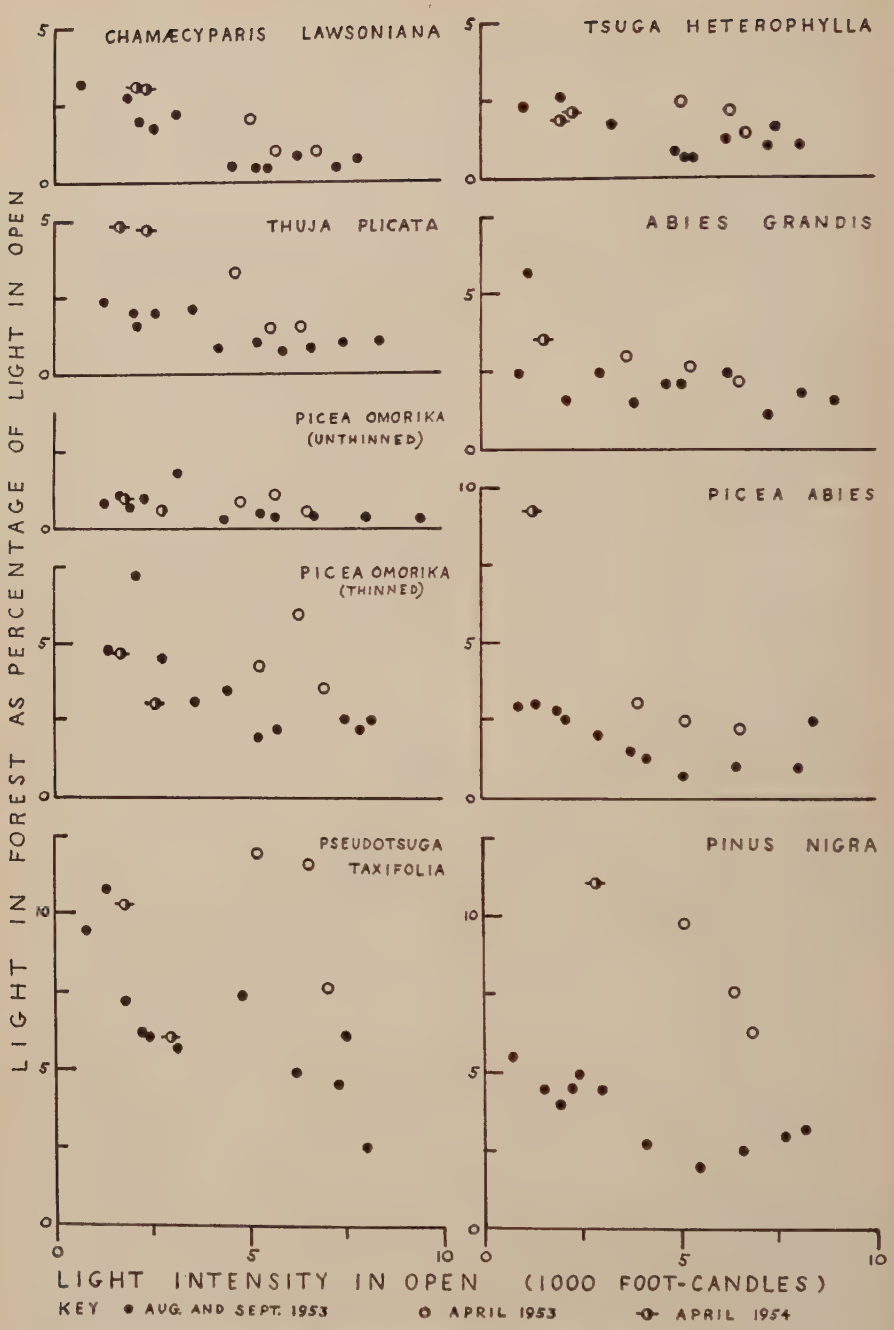
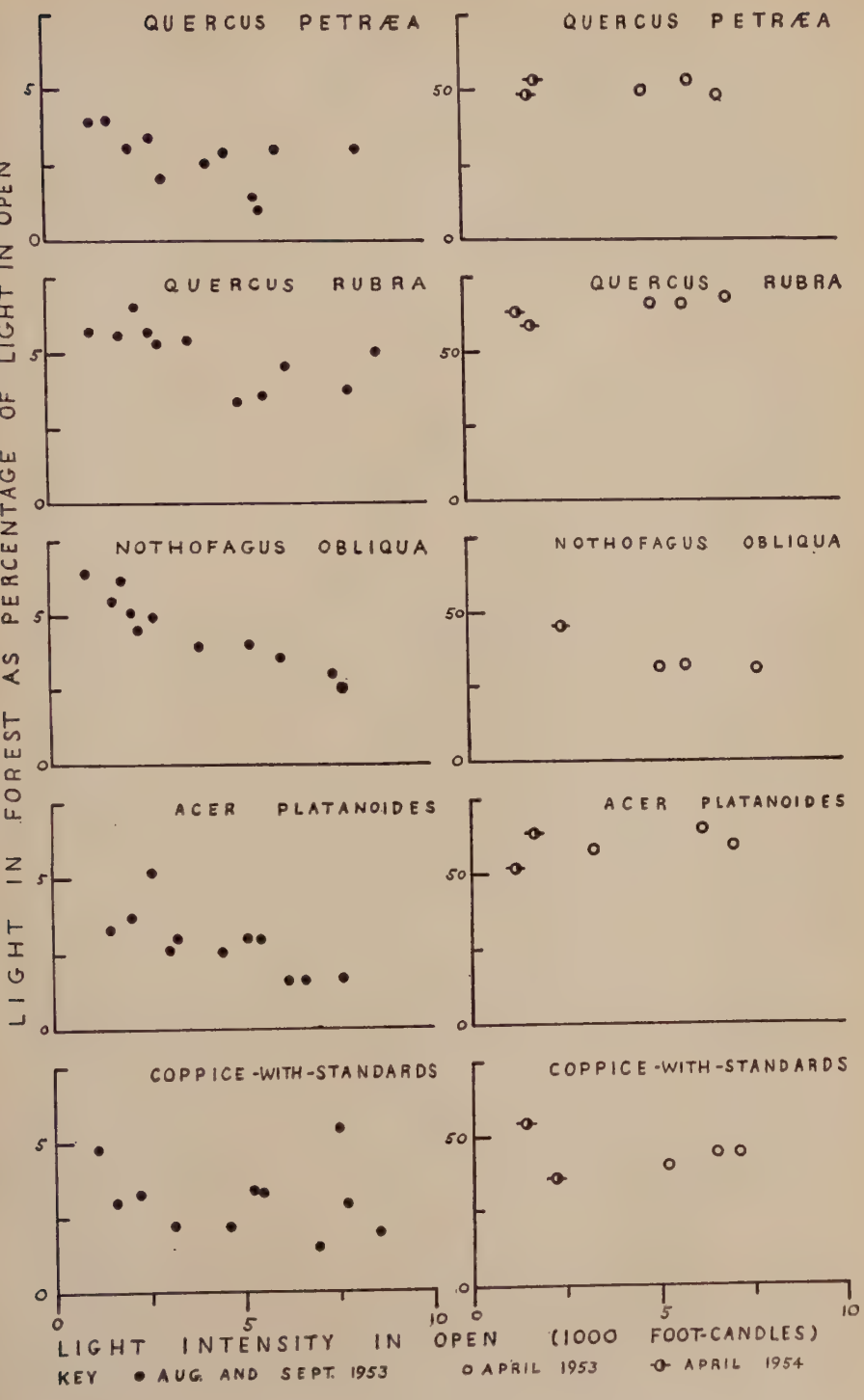


FIG. 1*a* (*above*) and FIG. 1*b* (*right*). Light penetration of tree canopies. Vertical scale adjusted for spring readings (*extreme right*).


QUERCUS PETRÆA
QUERCUS PETRÆA
QUERCUS RUBRA
QUERCUS RUBRA
NOTHOFAGUS OBLIQUA
NOTHOFAGUS OBLIQUA
ACER PLATANOIDES
ACER PLATANOIDES
COPPICE-WITH-STANDARDS
COPPICE-WITH-STANDARDS
LIGHT IN FOREST AS PERCENTAGE OF LIGHT IN OPEN
0
5
50
10
LIGHT INTENSITY IN OPEN (1000 FOOT-CANDLES)
KEY ● AUG. AND SEPT. 1953 ○ APRIL 1953 ⊖ APRIL 1954

All measurements were made between 10.00 a.m. and 2.00 p.m. G.M.T. and the order of sampling of the plots was varied to eliminate any effects due to diurnal fluctuations of the sun's altitude and strength, &c. Single values of light intensity were taken alternately in the open and at random positions under the canopy until a total of 25 pairs of readings were obtained. On virtually all days when readings were taken all the fifteen plots were sampled at least once and readings of light intensity in the open during the sampling period varied little. No observations were made during rain or when snow lay on the branches. The

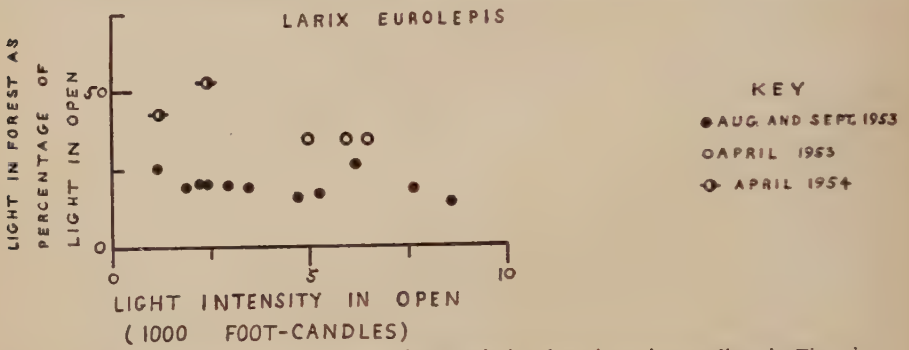


Fig. 1*c*. Light penetration of tree canopies. Vertical scale as in spring readings in Fig. 1*b*.

spring values were obtained between the 18th and 26th of April 1953, and on the 5th and 6th of April 1954, before the majority of deciduous species came into full leaf, and the summer readings were taken during the August and September of the intervening period.

AVERAGE LIGHT PENETRATING THE CANOPY

Numerous canopy types are represented in the various woodlands but in general the plots may be divided into two distinct groups, those planted with evergreen and the rest planted with deciduous tree species (Figs. 1 *a*, *b*, and *c*).

All of the evergreens in the plots are conifers and give a relatively intense shade throughout the whole year. Nevertheless, it is possible to recognize an annual régime of light climate; the conifer canopies absorbing and reflecting a smaller proportion of the sunlight in winter and early spring than in summer. A greater weight of leaf may be carried on the canopy during the summer period before the old leaves fall and as the new leaves develop. Shading in these plots is intense and in the summer months only 0·5 to 6·7 per cent. of the light reaches the forest floor. For comparable conditions of general light there is little difference between the light intensities in each plot for the two series of spring measurements. The only exception to this is when thinning was carried out during the course of the year as in the stand of *Picea abies* where a fourfold increase in the percentage of light penetrating the canopy occurred after a normal thinning.

The percentage values of light penetrating the canopies of the deciduous tree species are greater than for the evergreens of the same age, both in winter and summer. During the winter and early spring between 30 and 60 per cent. of the incident light penetrates the leafless canopy, the amount of penetration being in

direct ratio with the light in the open. Little significant difference occurs between the two sets of spring readings, except in the plots of *Larix eurolepis* and *Nothofagus obliqua*, which had begun to break into leaf during the time of the 1953 spring readings, and in addition the stand of *Nothofagus obliqua* had been thinned during the winter of 1953–4.

In summer the relationship between light intensity in the open and under the canopies of the deciduous species is much more complex. The most obvious feature is the greatly reduced light intensity inside the wood, when the trees are in full leaf, during the summer months as compared with the spring period. With

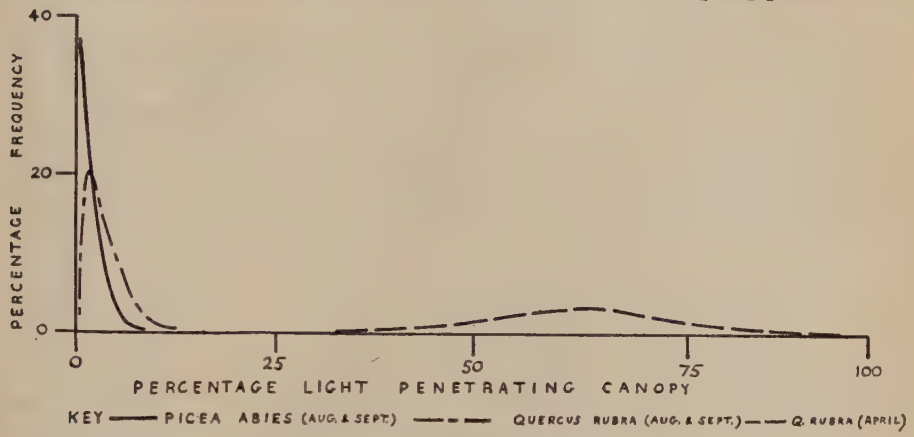


FIG. 2. Variation of light within the plot.

increased light intensity in the open during the summer a larger absolute quantity of light reaches the forest floor, but the percentage of light which penetrates the canopy decreases. This has been noted by Geiger (1), but to what extent it is due to variations in the amount of light passing through the leaves, or as Geiger suggests, to the non-directional diffuse light penetrating the canopy more easily, is not clear.

VARIATIONS IN THE LIGHT WITHIN THE PLOT

While the averages for the sets of readings give a reasonable picture of the differences between species and seasons they mask the wide variations within each plot. Random readings taken under a canopy which looks reasonably uniform show a wide range of light intensities and the distribution of these intensities is characteristic of the time of the year and the particular canopy. Typical differences between canopies are illustrated in the frequency distribution curves of Fig. 2.

DISCUSSION

Various factors determine the amount of light penetrating a forest canopy, and in particular the prior silvicultural treatment is of great importance. Normal forest thinnings made during the course of the year always resulted in considerably more light reaching the forest floor, but from the results of other investigations of canopy form and weight, it would seem that this may only be a temporary effect,

since after a normal thinning there is a tendency for the canopy gradually to develop to its former size. One plot of *Picea omorika* had been thinned just over a year previously, and although this plot is lighter than the unthinned plot the difference between the two is not so great as immediately after the thinning. The type of canopy characteristic of the species is also effective, the open canopy of *Pinus nigra* for instance absorbing and reflecting less light than the denser small-leaved canopies of the other well-stocked coniferous species. In general with a greater depth of canopy a smaller amount of light penetrates to the forest floor, the deep layered canopy of the coppice with standards giving more shade than the single layered canopies of the other hardwood species.

With comparable light conditions in the open the two sets of spring readings are not significantly different for each unthinned plot and it seems that in unattended plots the canopy and light penetration relationships remain fairly constant from year to year. In contrast well-marked seasonal changes occur in the canopies of the deciduous tree species and there is a well-defined, associated light régime. A less well-defined seasonal change of light penetration occurs in the evergreen stands and the decrease in light penetrating the evergreen canopies in summer is probably due to changes in the needles and to an increase in leaf numbers and weight during this period. A similar decrease was noted by Nägeli (3) who suggested canopy growth as a possible explanation.

The ground flora differs markedly both in weight and in the species present from plot to plot (5), and in general the more luxuriant floras are found in those plots with greater light penetration of the canopy either throughout the year or in the spring period. There is, however, very little natural regeneration in any of the plots and this may well be a result of low light intensity, although other factors may be involved, such as root competition, viability of seeds, and animal activity (2), (6). Despite the high light intensity in individual sunflecks, the average light for any day is low since the sunflecks move considerably during the course of the day.

ACKNOWLEDGEMENTS

We are grateful to the Forestry Commission, whose co-operation greatly assisted the investigation, and in particular to R. F. Wood and A. Westall.

LITERATURE REFERENCES

(1) Geiger, R.: *The Climate near the Ground.* Harvard University Press (1950).
(2) Grasovsky, A.: 'Some Aspects of Light in the Forest.' Yale Univ. Sch. of Forestry Bull. No. 23 (1929).
(3) Nägeli, W.: 'Lichtmessungen im Freiland und im Geschlossenen.' *Altholzbestände: Mitteil. Schweiz Anst. Forst. Versuchswesen*, 21 (2), 250 (1940).
(4) Ovington, J. D.: 'A Comparison of Rainfall in Different Woodlands.' *Forestry*, xxvii. 41 (1954).
(5) —— 'Studies of the Development of Woodland Conditions under Different Trees. III. The Ground Flora.' *J. Ecol.* 43, 1 (1955).
(6) Shirley, H. L.: 'The Influence of Light Intensity and Light Quality upon the Growth of Plants.' *Amer. Journ. Biol.* xvi. 354 (1929).
(7) Wood, R. F.: *The Forest Plots 1929–49. Guide to the National Pinetum and Forest Plots at Bedgebury.* Forestry Commission, xxi (1951).

THE INFLUENCE OF HEATHER MULCHING ON THE GROWTH AND NUTRIENT STATUS OF LAWSON CYPRESS

By L. LEYTON

(*Department of Forestry, Oxford University*)

SUMMARY

The application of a heather mulch in a heathland plantation of Lawson cypress (*Chamæcyparis lawsoniana* Parl.) has over a period of 8 years more than doubled the height of the trees compared with untreated controls. Analysis of the current foliage of trees from mulched and control plots reveals considerably higher concentrations of nitrogen and phosphorus in the former, indicating an increase in the availability of these nutrients to the trees presumably from decomposition of the mulching material and the suppression of the competing heather vegetation. Much of the beneficial influence of the mulch must however be attributed primarily to better moisture conditions, particularly during dry periods when the superficial roots of the trees are otherwise liable to desiccation.

INTRODUCTION

THE application of dead plant material to the surface of the soil around fruit trees and bushes with superficial root systems has been a common horticultural practice for a long time. Forest trees growing under conditions which promote the development of a shallow root system, as for example in heathland plantations, also respond most markedly to this treatment. Fabricius (1938) obtained a considerable increase in the growth of Norway spruce and Scots pine on a heather-dominated site in Germany by covering the vegetation surrounding the trees with mown plant material obtained in the vicinity, and similar striking results have been obtained using a heather mulch with Lawson cypress and Sitka spruce growing on heaths in Great Britain (Weatherell, 1953; Leyton, 1954). From investigations into the factors underlying this stimulation to growth (cf. Russell, 1950) there is little doubt that on dry sites much of the benefit is to be attributed to improved moisture conditions under the mulch, but it is also likely that a direct increase in nutrient availability to the trees, through leaching and decomposition of the mulching material and through the suppression of the competing ground vegetation, is of some importance. A characteristic feature of mulching with straw in orchards is an increase in the amount of exchangeable potassium in the soil and evidence has also been produced for an increase in nitrate production and phosphate availability (Wander and Gourley, 1938; Stephenson and Schuster, 1945). Investigations into the nutrient status of Sitka spruce trees growing on a heathland in Scotland (Leyton, 1954) have shown a significant influence of heather mulching on the concentrations of nitrogen, phosphorus, and manganese in the current needles, and in this particular case at least it appeared that much of the beneficial influence of this treatment on the growth of the trees was due to the increased availability and uptake of these nutrients, especially of nitrogen.

However, in order to confirm the generality of this response, it was considered worth while to carry out a similar investigation with a different tree species in a different part of the country.

EXPERIMENTAL MATERIAL AND METHODS

Advantage was taken of a heather mulching experiment with Lawson cypress set up in a heathland plantation on Wykeham Moor, Yorkshire (Weatherell, 1953, Experiment No. 58). The trees were planted in 1938 after medium depth double furrow ploughing and subsoiling and were given a dressing of basic slag. A heather mulch was applied to part of this plantation in 1945 and again in 1949, each time at a rate corresponding to about four times the amount of vegetation naturally growing on the area (approximately 20 metric tons of oven-dry material per acre). In 1949 the mean height of the mulched trees was 5 feet 3 inches compared with 3 feet 0 inches for the untreated controls.

In September 1953 twenty trees were selected at random from within the plantation, ten from the mulched plot and ten from the control, and samples of the current foliage, as near as possible to the terminal shoot, removed for subsequent analysis. After drying and grinding the leaf material was analysed for nitrogen, phosphorus, manganese, total ash, and total bases. Measurements of tree height were made at the time of sampling.

RESULTS AND DISCUSSION

Complete data on the height growth and nutrient status of the individual trees, together with the mean values and standard errors for the treatments, are given in Table I.

TABLE I. *Tree heights and concentrations of nutrients in the current foliage*

Controls						*Mulched*					
Height (*ft.*)	N	P	Mn	*Ash*	*Total bases* (*m.e./100 g. D. wt.*)	*Height* (*ft.*)	N	P	Mn	*Ash*	*Total bases* (*m.e./100 g. D. wt.*)
	(% *D. wt.*)						(% *D. wt.*)				
3·2	0·46	0·056	0·36	6·38	143	4·7	1·94	0·21	0·14	4·04	37
3·8	0·52	0·058	0·23	6·75	143	5·0	2·35	0·27	0·14	4·22	27
4·2	0·47	0·067	0·24	5·05	103	7·2	3·59	0·40	0·16	3·83	40
3·5	0·55	0·045	0·37	5·53	131	8·6	2·6	0·2	0·13	3·72	36
4·9	0·60	0·091	0·35	5·61	91	9·0	2·32	0·25	0·12	2·98	32
3·0	0·53	0·065	0·21	3·05	50	7·8	2·47	0·22	0·14	3·26	36
3·2	0·53	0·087	0·34	4·52	72	7·1	2·42	0·24	0·16	3·25	41
3·3	0·75	0·042	0·21	4·83	117	9·4	2·00	0·22	0·09	3·52	21
3·0	0·91	0·065	0·24	*	*	8·4	2·87	0·27	0·17	3·49	43
3·0	0·60	0·055	0·25	7·74	133	7·5	2·26	0·23	0·15	3·52	49
Mean 3·5	0·59	0·063	0·28	5·50†	109†	7·5	2·49	0·26	0·14	3·58	36
±S.E. 0·2	0·004	0·014	0·02	0·46	10·9	0·5	0·15	0·02	0·01	0·12	2·5

* Insufficient material available. † Based on nine samples only.

It will be seen from these results that over a period of 8 years the heather mulch has more than doubled the height growth of the trees and that this increased growth is accompanied by a considerable rise in the concentrations of nitrogen and phosphorus in the current foliage. It follows therefore that mulching has led to a pronounced increase in the availability of these nutrients to the trees, but within the limited scope of this investigation it is not possible to state with certainty whether the response in growth is directly attributable to this increase. In contrast to other tree species little or no work appears to have been done on the mineral nutrition of Lawson cypress, so that there is no basis for comparison with other results for this species. Nor is there any evidence of a consistent relationship between the height growth of the trees and the concentration of either nitrogen or phosphorus in the foliage which might be used as an indication of a limiting influence of these nutrients on growth. Nevertheless in view of the pronounced nitrogen deficiencies in these heathland soils (Leyton, 1954) and the particularly low concentration of this nutrient in the foliage of the control trees, it is most likely that the growth of the trees has been stimulated by an increase in available nitrogen: under these conditions an increase in available phosphate would then result in a further stimulation to tree growth. The significant fall in the manganese and base concentrations in the foliage, following the application of the mulch, does not necessarily mean that the mulch has decreased the availability of these nutrients to the trees; it might be explained on the assumption that the uptake of these nutrients has not kept pace with the pronounced increase in dry weight production of the foliage, resulting therefore in a corresponding 'dilution' of the nutrients in the tissues. Inspection of the individual values given in Table I for the mulched trees does in fact suggest some inverse relationship between tree height and the concentrations of ash, manganese, and total bases in the foliage, which is consistent with this assumption.

To a certain extent, therefore, the response of Lawson cypress to heather mulching is similar to that previously found with Sitka spruce (Leyton, 1954) in that in both cases there has been a marked improvement in the nitrogen and phosphorus status of the trees.

The actual cause of the increased uptake of these nutrients is difficult to define since it is very probable that a complex of factors is involved. From the fact that the mulching material eventually disappears over a period of years and has to be replaced it would seem that decomposition of this material plus that of the suppressed vegetation beneath the mulch is the ultimate source of the extra nitrogen and phosphorus. On the other hand even in the untouched heath the raw humus layer itself is a potential source of nutrients (it may for example contain up to 2 per cent. nitrogen on a dry weight basis), yet under ordinary field conditions these nutrients are released in a form available to the trees only to a very small extent. The mulch, therefore, must also provide conditions which promote the decomposition of the organic material, and there is little doubt that the improved moisture status under the mulch is a particularly important factor. Not only will this stimulate microbiological activity in the soil but also the growth of the tree roots themselves which are commonly found ramifying profusely in

the lower moister regions of the mulch. Under the conditions normally prevailing in heathland plantations, tree roots are, to a great extent, restricted to the superficial raw humus layer which readily dries out during the dry summer months, often to such an extent that the superficial roots are completely desiccated. The beneficial influence of the mulch in improving these conditions is readily seen in the data presented in Table II which compares the amount of available water in the raw humus under the mulch with that in the control plot of the Lawson cypress plantation under investigation.

TABLE II. *The influence of heather mulching on the amount of available water in the raw humus*

Date of sampling	*Available water (in.)*	
	Mulched plot	*Control plot*
June 1950 . . .	1·10	0·067
September 1950 . .	1·26	0·59

Data of P. J. Rennie (unpublished).

During the relatively dry month of June the effect of the mulch on available water in the soil is particularly marked: this may be attributed not only to the physical nature of the mulch itself but also to the suppression of the heather vegetation which must be responsible for a great deal of competition with the trees for the low amounts of water available in the soil during such dry periods.

CONCLUSIONS

The considerable stimulation to the growth of Lawson cypress obtained by heather mulching must be attributed to a complex of factors of which improved moisture conditions appear to be of particular importance, especially during the relatively dry summer months when the superficial roots of the trees are liable to desiccation. There is strong evidence that the increased uptake of nitrogen and phosphorus is also of great importance considering the pronounced deficiency of these nutrients characteristic of heathland soils. It is of course possible that the improved moisture conditions themselves are directly or indirectly responsible for the increased availability of nitrogen and phosphorus to the trees, but other factors such as the suppression of the competing heather vegetation and the provision of an extra source of nutrients in the mulching material must also be taken into account.

As a practical measure to be applied on a large scale, heather mulching is of course uneconomic, but from the fundamental point of view the results of these experiments provide very valuable information as to the factors responsible for the poor growth of the trees under ordinary heathland conditions.

ACKNOWLEDGEMENTS

The author is indebted to H.M. Forestry Commission Research Branch for facilities provided in this investigation, to Mr. P. J. Rennie for permission to use

his unpublished data on water relations and to Mr. J. Dexter for help in the analytical work.

LITERATURE REFERENCES

Fabricius, L. (1938): *Bodendeckung mit Pflanzenstoffen.* Forstwiss. Cent. 60, 1.

Leyton, L. (1954): *The Growth and Nutrition of Spruce and Pine in Heathland Plantations.* Inst. Pap. Imp. For. Inst., Oxford, No. 31.

Russel, E. J.: *Soil Conditions and Plant Growth.* Longmans, Green & Co., 8th ed. 1950.

Stephenson, R. E., and Schuster, C. E. (1945): 'Effect of Mulches on Soil Properties.' *Soil Sci.* lix. 219.

Wander, I. W., and Gourlay, J. A. (1938): 'Available Potassium in Orchard Soils as affected by a Heavy Straw Mulch.' *J. Am. Soc. Agron.* xxx. 438.

Weatherell, J. (1953): 'The Checking of Forest Trees by Heather.' *Forestry*, xxvi. 37.

REVIEWS

Thinning Problems and Practices in Denmark. By Carl Mar: Möller, Jörgen Abell, Thöger Jagd, Flemming Juncker. State University of New York, 1954. Price 80 cents.

Review by F. C. Hummel

THE reason why an American university should publish a book on thinning problems and practices in Denmark is explained in the foreword:

'Believing that people of all nations will profit from exchanging technical information on Forestry, the State University of New York College of Forestry at Syracuse plans to issue a series of publications dealing with timely forestry subjects of world-wide significance.

'This publication on *Thinning* as practiced in Danish forests is offered by the College as the first number in its new World Forestry Series.'

A brief introduction by Professor Svend O. Heiberg, who is Professor of Silviculture at the College of Forestry at Syracuse, is followed by a paper by that great Danish authority on silviculture, Professor Carl Mar: Möller, entitled: *The Influence of Thinning on Volume Increment.* After dealing briefly with some of the earlier German and Danish work he discusses the results from all the more important Danish thinning experiments since 1935. Foresters who are not already familiar with the detailed accounts of these investigations which have been published in recent years will welcome this convenient summary. Most of the experiments are in beech and Norway spruce and their main value lies in the fact that they are among the oldest experiments to test the effects of very heavy thinning treatments. Möller then devotes a section to *Experiments and Investigations outside Denmark since about 1935*, but this title is somewhat misleading because he discusses only a limited number of experiments and ignores some important work. For example, there is no mention of Craib's investigations in South Africa or of De Philippis's book *I diradamenti boschivi nella scienza, nella sperimentazione, nell' arte colturale*, which is probaby the most comprehensive and authoritative review of thinning research that has yet been published. The thinning experiments described by Möller confirm the evidence from other sources that, subject to some qualifications, within fairly wide limits the volume increment per unit area is not influenced appreciably by the density of stocking. There is as yet not much precise information on the ecological and physiological factors which combine to produce this result, but Möller gives a useful summary of the little that is known and puts forward some interesting hypotheses which may serve as a starting-point for experimental work to elucidate these factors.

In his second paper, *Denmark as an International Testing Area*, Möller describes the main features of Danish thinning practice. Like most British foresters their Danish colleagues do not thin according to any rigid thinning grades, but look for the best trees and give them what help they appear to need at the time. There is of course some controversy as to what are the 'best' trees and how drastic the thinnings should be in order to favour them; but there appears to be general agreement among Danish foresters that a low density of stocking is desirable at least during the latter part of the rotation and that thinnings should be carried out very frequently, every one or two years if possible.

With this general discussion on thinning practice Möller sets the stage for the three papers which follow and in which three foresters of standing express their views on issues that are controversial.

J. Abell, Forest Supervisor of Hvidhilde Forest District, Fumen, is an adherent of what he calls the 'wait and see' method of thinning. Under this method, thinnings start early and are repeated at frequent intervals, but the stocking is kept fairly dense for a considerable number of years, the exact period depending on species, site, and the condition of the crop. Later there is a change over to heavy thinnings.

Thöger Jagd, Forest Supervisor of Bregentved Forest District, describes the 'active' method of thinning which differs from the 'wait and see' method by being heavy from the start.

The arguments put forward in favour of each of these methods are familiar: they are much the same as are heard at any meeting of foresters in Britain when the thinning of young plantations is discussed.

The 'selection' thinning advocated by Flemming Juncker who is director of a sawmill and owns woodland both in Denmark and in the U.S.A. is less familiar although, as Juncker points out, the idea is by no means new having first been described by Borggreve in Germany. In a 'selection' thinning the largest trees are removed in thinnings and the best of the co-dominants are favoured. There are obvious objections to this selection against vigour quite apart from the danger that in unskilled hands it may degenerate into a crude exploitation felling; the author, however, puts up a very plausible argument in favour of the method under certain conditions and quotes experimental evidence to show that the removal of the fastest growing trees in the crop does not diminish the volume increment per acre. Having read this paper the reviewer certainly feels that the method is worth testing in Great Britain in stands where ordinary thinning methods lead to the production of timber with too wide rings.

All figures quoted in the text and tables are in British units of measure, but there is nothing to indicate whether volumes and basal areas are in true measure or in quarter girth or hoppus measure. It appears, however, that the data for the Norway spruce plots at Bowmont are given in hoppus measure and all other data in true measure which has to be multiplied by 0·7854 in order to arrive at the hoppus equivalent.

The main criticism of the book is that there is some careless wording which cannot wholly be explained by the fact that the articles are either translations or that English is a language foreign to the authors. For example, the observed fact that 'within certain wide limits the volume increment is not influenced by density of stocking' is referred to as a 'theory' and views on thinning are described as 'thinning philosophies'. This occasional misuse of words is irritating but does not greatly reduce the value of this informative and thought-provoking little book which can be recommended to all foresters in Britain as our thinning problems are not dissimilar from those confronting our colleagues in Denmark.

American Forest Management. By Kenneth P. Davis. McGraw-Hill Book Company, Inc., New York, 1954. Pp. 482. Price $7.50.

Review by W. M. McNeill

THIS is the most recent addition to 'The American Forestry Series' which already contains some classic textbooks and some of the most authoritative works on forestry subjects in the English language. Professor Davis's extremely interesting and valuable book replaces *Management of American Forests* published in the same series in 1935 and written by Professor D. M. Matthews who was Professor Davis's predecessor in the Chair of Forest Management in the University of Michigan.

The book is divided into two parts. Part I—'Foundations of Management'—contains 281 pages arranged in 13 chapters. This portion of the book deals with the forest and shows 'how it can be organized effectively as a productive entity' (author's preface). It covers very completely, clearly, and logically all the fundamental knowledge regarding site, stocking, growth, and yield necessary for the foundations of good management. Methods of determining and regulating the yield are dealt with from a practical viewpoint, both in the management of even- and uneven-aged stands, and particularly valuable are the actual examples or 'case analyses' given of the application of the different methods. Questions regarding the determination of the rotation and the subdivision of the area for management purposes are very thoroughly examined, and finally the form and preparation of management plans are dealt with.

Part II—'Valuation'—contains 166 pages arranged in 8 chapters. The author argues that management of forests is so intimately bound up with economic considerations that he has devoted the second part of his book to a concise but comprehensive examination of 'valuation principles and procedures applied to forest management' (author's preface). In this part concepts of interest are explained, and valuation of forest land and forest crop is very exhaustively treated with numerous examples. There is a chapter on the 'valuation of financial alternatives' and this part ends with an examination of the appraisal of damage, again with an actual example.

The book is intended primarily as a textbook for students of forestry in America. In many ways it fulfils for American students the purpose which Schlich's famous Volume III of his Manual of Forestry fulfilled for generations of British students, but in a very much more practical manner, in much fuller and complete degree, and with direct emphasis throughout on North American conditions and problems.

There is still a tendency among British foresters to consider American textbooks on forestry subjects as unsuitable or insufficient for our needs, and perhaps especially towards forest management this attitude is particularly exaggerated. This is an unfortunate, short-sighted, and quite mistaken attitude. Admittedly this book expresses out-turn in board feet and emphasizes aspects of management connected with policies and practices of forestry which are unfamiliar to us in this country, but the great merit of this book is the way in which fundamental principles are applied to the practical business problems of managing the forests of a particular country. As the author mentions, 'to a considerable degree the forests themselves set the general pattern of management' (p. 21). The time has come in British forestry for us to work out our own application of management principles and not expect to find the answers readymade from continental or American textbooks. Professor Davis stresses throughout his book that the job of managing a forest is a business and 'in fundamentals a forest business is no different from any other business, the differences arise in application' (p. 7).

We are well aware these days that in the art of business management America can teach us much. A recent report on the productivity investigations which have been made by British business experts in the U.S.A. underlines the conclusion that the general lesson of the survey is that there is room for improvement in this country 'mainly in the quality, energy and efficiency of management'. This applies to British forest management as much as to any other business. It is for this reason that Professor Davis's book is most useful and important for those of us who have to teach and learn forest management. The author constantly emphasizes what the Director of Research in the Forestry Commission has recently stated, namely, that 'management is not an end in itself; it is nothing more than an instrument of policy' (*Scottish Forestry*, July 1954).

It is no overstatement to say that we have read this book throughout with interest and

pleasure. Obviously it is not the ideal textbook for British forestry students, but it is one in which they will find valuable ideas convincingly stated and especially where they will get most useful suggestions as to how they might approach urgent problems of forest management in this country. It is a pity that American terminology differs from our own, and care has to be taken to understand the special meaning of such common terms as 'working circle', 'stand', 'irregular forests', 'reserve growing stock', &c.

Unlike so many books on the subject, not excluding some from America, this one is very easily read. The reasoning is sound and lucid although it would be possible to take exception to some of the economic doctrine or to criticize some of the working plan headings. One is impressed by the honest way in which all aspects of the subject are treated, and the general impression left is that we should like to learn forest management, as a subject, from this teacher. Formulae and figures are unavoidable but are kept well within bounds. A complete bibliography is given relating to each chapter. One comes across somewhat picturesque and unusual words such as 'meaningfully', 'hindsight', 'overly', and 'happenstance' but these lend added interest to a vital and enthusiastic book.

The dust-cover states that the book 'encourages people to think with balance and directness about management problems'; we agree.

Forest Mensuration. By H. Arthur Meyer, Penns Valley Publishers, Inc., Pennsylvania, 1953. Pp. 357.

Review by T. E. Edwardson

PROFESSOR H. Arthur Meyer has followed his recent joint book on forest management with this companion volume on *Forest Mensuration*, thus adding a third to the American textbooks bearing this title.

With the recently revised editions of Bruce and Schumacher (1950) and Chapman and Meyer (Demeritt) (1949) in mind, and not forgetting Professor Spurr's *Forest Inventory* (1952), the British forester may well wonder what extra information he is likely to find in this latest publication.

The answer lies in that third of the book which Professor Meyer devotes to methods of forest growth determination. For a number of years now he has been a leading investigator of this difficult, dynamic aspect of forest inventory, and in the part of the book (Part III) dealing with increment, he brings together and makes a whole of a number of the ideas and techniques that he has expounded in the past in the *Journal of Forestry* and in publications of Pennsylvania State College. Recent, quite widespread activities in Britain both in connexion with 'check' or 'periodic inventory' methods of following stand increment and with the more varied, short-term methods used in the 1947–9 national census have interested a growing number of foresters in the subject of increment: these will find in Professor Meyer's chapters 10 to 13 a comprehensive and authoritative discussion of the general concepts of growth of both trees and stands and of the fundamental problems of increment determination and the possible practical solutions.

Closely related to 'control method' working is our fairly recent interest in planned, 'irregular' or 'group selection' management, and appropriate to a general appraisal of this topic is the last section of Professor Meyer's book (Part IV), a part in which he covers the structure and growth of even-aged forests, including the related items of yield tables and stocking density, and, in a final chapter, the mensurational aspects of the problem of structure and growth of uneven-aged forest.

Many features of the rest of the book (Parts I and II) are reminiscent of the two earlier textbooks, though there are, inevitably and desirably, differences in emphasis and presenta-

tion. In support of a prefacing remark that 'the development of new techniques in forest mensuration through the application of statistical methods and, more recently, through the application of aerial photographs, has greatly increased the scope of this basic field of forestry', Professor Meyer gives early prominence in the book to mathematical and statistical prerequisites (40 pages in Part I) and to the application of aerial photographs (20 pages in Part II).

Throughout the book, in the selection of subject-matter, Professor Meyer has given foremost consideration to the practising forester, by confining himself to mensurational methods suitable for ordinary field use. In support there are many worked examples illustrating principles and techniques. At the same time there are periodic references to more complex problems likely to interest the specialist. Both classes of reader will find a full and catholic selection of references at the end of each chapter and a co-ordinating Index of Names in the appendix: Professor Meyer's early, extensive Swiss experience has encouraged a balance in the reference selection which will further increase the book's appeal to the non-American reader.

Part II, on the measurement of logs and trees and the matter of forest inventories, contains much for 'home consumption', in particular log-rules and land measurement, but for the general reader there are also basic chapters dealing with felled and standing tree measurement, and valuable chapters on the construction of volume tables, and statistical considerations in the design, intensity, and sampling error of forest enumerations.

The book is well provided with line drawings, graphs, summary tabulations, footnotes, and a variety of appended ready-reckoner and statistical tables. Altogether, a further welcome instalment of 'American aid' to help British foresters along the way until such time as a successor to Jerram produces a mensurational textbook with a strong Commonwealth flavour.

Forests of France. By J. L. Reed. Faber and Faber, Ltd., 24 Russell Square, London, W.C. 1, 1954. Pp. 296. 9 plates and 1 map. Price 21*s*.

Review by N. V. Brasnett

THIS is a very pleasant guide-book to the principal forest regions of France, preceded by a short account of the general forest history and policy of the country and of its Forest Service. Starting in the oak forests of central France, with Tronçais as the main example, the author passes to Fontainebleau, the beech woods of the north (Lyons-la-Forêt, Compiègne, &c.), the Ardennes, the Langres plateau, the plain of Bresse (Chaux), the Morvan, the Charollais, the Massif Central, the Vosges and Haguenau, the Jura (Risoux, &c.), the Alpes (Ban), Mt. Ventoux, Provence, the Pyrenees, and the Landes.

There are vivid descriptions of the scenery, characteristics, life, and industries of the various districts. The vicissitudes of individual forests under their successive owners in war, peace, and economic crises are recounted with a wealth of folklore, legends, and anecdotes. A final chapter on French poplar growing includes a delightful description of the Marais Poitevin district near Niort, which has been called the Green Venice.

A useful feature of the book is the reference to the road numbers on which the forests lie and their distances from convenient centres.

Some professional foresters might perhaps prefer to hear, for instance, about the work of Duchaufour in the forest of Compiègne, rather than about how Napoleon consummated his marriage with Marie-Louise there. They would be in the minority, and the book is not meant for them.

However, foresters will notice, and laymen should be warned, that when Mr. Reed does

venture in to the technical field he is not always reliable. We are told on the dust-cover that the author 'is no academic', and apparently he has sometimes repeated a personal opinion expressed to him by an individual forester as authoritative statement. For instance, that hornbeam is not a native of Europe, that holly can quickly impoverish a forest soil, and that 'it is difficult to grow really first-class timber in a *jardiné* forest'. A lot depends, of course, on what you understand by *jardinage*. When management terms are translated there is sometimes confusion, as when we read that the forest of Villers-Cotterêts (33,000 acres) 'is divided into sixteen compartments of which thirteen consist of high forest', and that of these 'one-third of each compartment normally consists of young growth'. Presumably there are thirteen felling series in the high forest working circle, and a regeneration block of several normal sized compartments in each.

Incidentally I hope there will be no trouble 'in the attractive little town of Lyons (-la-Forêt) with its comfortable little inn' between two good friends of mine, who are both innkeepers.

Eight of the well-chosen illustrations were supplied by the French Administration and are really beautiful pictures by a photographer named Toulgouat.

Certainly this is a book which I should like to have in my car during a holiday in France. It is one which, read by the fire at home, will bring back happy memories and stimulate the planning of future tours.

Full-Tree Logging—A Challenge to Research. By A. Koroleff. Paper and Pulp Research Institute of Canada; obtainable from McGill University Book Store, 3480 University Street, Montreal. Pp. 101, illustrated. $3.50.

Review by E. G. Richards

ANY author who gets to grips with such technical terms as 'jackpots', 'hot-logging', and 'dynamometration' in the first dozen or so pages and discusses the merits of chlorophyll preparations by page 60 is likely to have something out of the ordinary to say, particularly when one finds that he is a graduate in forestry not only of Washington and Yale but also of the University of St. Petersburg. Koroleff in his *Full-Tree Logging–A Challenge to Research* fulfils these expectations as he outlines what is involved in full-tree logging, drawing on data published in a number of countries as well as on his own wide experiences of forestry. The information drawn from recent Russian literature is particularly noteworthy because of the intrinsic interest of the matter presented and because authoritative translations from Russian by a forester with training and experience both in that country and North America are something of a rarity.

Though the loose-leaf principle has been used for binding the photolithographic reproduction from typescript, line-drawings, and photographs, the quality of the paper used is high—as indeed might be expected of a publication of the Pulp and Paper Research Institute of Canada.

About one-third of the book is devoted to a description of the methods hitherto used to fell and drag the complete tree, with its crown still on, from stump to 'landing', and the methods used to branch and convert it at the 'landing'. For those interested in the mechanization of forestry operations, there is a description of the Russian felling-skidding machine which operates on producer gas and by means of which 'trees are felled directly onto [the] tractor which carries them to [the] landing'. It is interesting to note that the Russians appear to reorganize their work so as to utilize to the full the capabilities of new machines rather than—as sometimes happens—merely to introduce them into some con-

ventional logging system where they may or may not earn their keep. The Russian mechanical branching tools and the Finnish branching machine—both described in this section—may seem more practical today than they would have done a short time ago when the peace of our sylvan countryside was undisturbed by the grinding and hammering of mechanical bark peelers.

Those foresters who would hasten to pour strong silvicultural scorn on anyone having the temerity to advocate the removal of branches, leaves, and twigs from the forest, must first read the 13 pages on silviculture and forest protection written by Koroleff and the 15 pages of Appendix A, on the possible effects upon forest soils of the removal of tree crown materials, contributed by four independent authorities.

Apart from a discussion on full-tree logging abroad (i.e. in countries other than Canada) the remainder of the book is devoted to a discussion of the fuller utilization made potentially possible when branches and bark, not to mention leaves, are brought to central points where they either may be collected at reasonable cost and dispatched to a factory or processed on the spot.

The Queen Elizabeth Forest Park Guide. Edited by John Walton and issued by the Forestry Commission. Edinburgh: H.M.S.O. Pp. 80, illustrated, with map inside back cover. To fit in pocket. 3*s.* 6*d.*

Review by C. W. Scott

THIS is an excellently written, illustrated, and reproduced guide to what the Chairman of the Forestry Commission calls in the foreword the most beautiful of the National Forest Parks. To commend the booklet is a special pleasure to one who knew the area well 40 years ago, as a Glasgow undergraduate, and now scans the guide and its delightful photographs in a distant part of the southern hemisphere.

Lord Radnor's foreword very rightly stresses how accessible is this National Park to the people of Glasgow and Edinburgh, how much is owed to the late Lord Robinson of Kielder Forest and Adelaide for what he did for British forestry in the creation of such parks, and the duty of those who visit the Park to use its amenities decently and with regard for others.

There are ten chapters or sections, dealing with the geology, botany, animals, forestry, folklore, Gaelic names, hill walks, and literature of the Park, plus a very useful section of general information and a good map. The standard is high, with much knowledge well summarized and purveyed.

Professor John Walton of the Chair of Botany in the University of Glasgow is the editor, assisted by Mr. H. L. Edlin of the Forestry Commission, who contributes a specially good section on the literature of the Trossachs. He points out that Wordsworth could walk as well as write, his daily mileages in 1803, with his sister Dorothy, being impressive!

The account on pp. 21 to 23 of the changes in the bird life associated with the new forest plantations, as they grow up, is particularly interesting; and one is glad to read on page 26 that the raven and peregrine falcon nest within the Park. The sections on the botany, geology, and fishes of the area are worthy of the Departments of Glasgow University concerned, so long led by Professors F. O. Bower, J. W. Gregory, and Sir John Graham Kerr, names still held in great esteem and affection by those who were privileged to study under them.

The good taste and high standard of reproduction in this guide are a great credit to all concerned. They are worthy of the very lovely and famous parts of Scotland which they portray, the Trossachs and Loch Lomond.

LIST OF MEMBERS

OF THE

SOCIETY OF FORESTERS OF GREAT BRITAIN

AS AT 23 MARCH 1955

Explanatory Note

F.C.	Forestry Commission.
F.P.R.L.	Forest Products Research Laboratory.
I.F.I.	Imperial Forestry Institute.
M. of A.	Ministry of Agriculture.
M. of A. (N.I.)	Ministry of Agriculture of Northern Ireland.
P.F.O.	Private Forestry Officer.
R.B.G. (Kew)	Royal Botanic Gardens, Kew.
R.B.G. (Edin.)	Royal Botanic Garden, Edinburgh.

FELLOWS

Ackers, C. P., of Huntley.
Adkin, B. C., Coll. of Estate Mangt.
Aitkins, A. E., Consultant.

Backhouse, G. W., F.C.
Ballance, G. F., F.C.
Barrington, C. A. J., F.C.
Beresford-Peirse, Sir Henry, Bt., F.C.
Best, F. C., F.C.
Blair, Sir James Hunter, Bt., of Blairquhan.
Blanford, H. R., I.F.S. (retired).
Bloomer, Leonard, Consultant.
Broadwood, R. G., F.C.
Brown, Gilbert, Estate Factor.
Brown, J. D.
Brown, Thomas, Consultant.
Burgess, F. G., M. of A. (N.I.).

Cameron, G. J., Head Forester.
Cartwright, K. St. G., F.P.R.L.
Chalk, Dr. Laurence, I.F.I.
Champion, Prof. H. G., I.F.I.
Connell, C. A., F.C.
Courthope, Baron (Honorary Fellow).
Crooke, Dr. Myles, F.C.
Cruickshank, Hector, F.C.
Currie, J. H., F.C.

Dallimore, William, R. B. G. (Kew) (retired).
Davey, Reginald, Consultant.
Day, W. R., I.F.I.
Denman, Dr. John.
Dixon, E. E., F.C.

Edlin, H. L., F.C.

Feaver, B. R., F.C.
Fergusson, D. C., Edinburgh Univ.
Finding, S. L.
Fisher, Dr. R. C., F.P.R.L.
Fitzherbert, J. T. L., F.C.
Foggie, Alistair, Gold Coast.
Fossey, R. E., F.C.
Fraser, James, F.C.

Galloway, J. A.
Galloway, R. A. (Secretary).
Garfitt, J. E., Consultant.
Gibson, W. N., F.C.
Glover, Sir Harold, I.F.S. (retired).
Goodwin, J. F., F.C.
Gorrie, Dr. R. M., I.F.S. (retired).
Gosling, A. H., F.C.
Grant, David, F.C.
Guillebaud, W. H., F.C.

Hanson, H. S., F.C. (retired).
Harker, M. G., F.C.
Harris, C. M., Consultant.
Harrison, P. D.
Hide, R. H., P.F.O.
Hiley, W. E., P.F.O.
Hodson, G. A., Consultant.
Hummel, F. C., F.C.

James, J. E., F.C.
James, N. D. G., Land Agent.
Jay, B. A.
Jones, E. W., F.C.

Kitchingman, G. D., F.C.

Laing, Dr. E. V., Aberdeen Univ.
Lamb, J. A., F.C.
Langley-Taylor, G., Land Agent.
Larsson, Capt. O. G., Canada.
Laurie, M. V., F.C.
Le Sueur, A. D., Consultant.
Long, A. P., F.C. (retired).

McClelland, Henry, M. of A.
Macdonald, James, F.C.
Macdonald, J. A. B., F.C.
Macdonald, J. Maxwell, of Largie.
MacGregor, W. D., Consultant.
Mackay, J. W., F.C. (retired).
Mackenzie, J. M. D., I.F.S. (retired).
Macmillan, H. R., Canada.

McNeill, W. M., Aberdeen Univ.
Makins, F. K., Consultant.
Milne-Home, Sir John, Elibank.
Mobbs, Prof. E. C., Univ. Coll. of N. Wales.
Mould, R. C. L., Consultant.

Newton, R. W. B., Chartered Surveyor.

Oliphant, J. N.
Oliver, F. W. A., F.C.

Palmer, R. W. V., I.F.S. (retired) (Editor).
Paterson, Alex., F.C.
Peace, T. R., F.C.
Pearson, F. G. O., F.P.R.L.
Pearson, Sir Ralph S., I.F.S. (retired).
Penistan, M. J., F.C.
Phillips, Dr. E. W. J., F.P.R.L.
Popert, A. H., F.C.

Redmond, James, Australia.
Rees, T. I.
Rendle, B. J., F.P.R.L.
Robbie, T. A., F.C.
Robertson, W. A., I.F.S. (retired).
Rogers, S. W., F.C.
Ross, A. H. H., F.C.
Rouse, G. D., F.C.
Ryle, G. B., F.C.

Sangar, O. J., F.C.
Sanzen-Baker, R. G., F.C.
Sayres, R. J., Consultant.
Scott, C. W., F.P.R.L. (retired).
Scott, Frank, Consultant.
Smith, R. H., F.C.
Smith, Prof. Sir William Wright, R.B.G. (Edin.)
Steven, Prof. H. M., Aberdeen Univ.
Stewart, Prof. A. B., Aberdeen Univ.
Stewart, I. J., F.C.
Stileman, D. F., F.C.
Stirling-Maxwell, Sir John, Bt. (Hon. Fellow).
Stocks, J. B., F.C.
Streets, R. J., Cyprus.

Tansley, Prof. Sir Arthur G., Nature Conservancy.
Taylor, Sir William L., F.C. (retired).
Thom, J. R., F.C.
Thompson, C. H., Cambridge Univ.
Thomson, Prof. (Emeritus) T., Univ. Coll. of N. Wales.
Thomson, W. P., F.C.
Trevor, Sir Gerald, I.F.S. (retired).
Turner, George.

Urquhart, B. P., Consultant.

Walker, James, Consultant.
Warrack, G. C., Canada.
Watson, Harry, F.C. (retired).
Watt, Dr. A. S., Cambridge Univ.
Watt, Andrew, F.C.
Watts, H. C.
Weir, A. H. W., Edinburgh Univ.
Williamson, J. Q., F.C.
Wilson, Dr. S. E., Wood Technologist.
Woods, R. P., T.D.A.
Woolridge, T. H., Timber Merchant.
Wright, H. L., I.F.S. (retired).

PROFESSIONAL ASSOCIATES

Aaron, J. R., F.C.
Abraham, M. F., Nairobi.
Aldhous, J. R., F.C.
Allison, B. J., F.C.
Anderson, Prof. Mark L., Edinburgh Univ.
Aston, S. C.

Baltaxe, Robert, Iraq.
Barber, S. C. L., P.F.O.
Batters, G. J. L., F.C.
Begley, C. D.
Bell, T. I. W., F.C.
Best, Hon. J. W., I.F.S. (retired).
Blunt, H. S., Consultant.
Bolton, Lord, Bolton Hall.
Braithwaite, J. D., Timber Merchant.
Brasnett, N. V., Oxford Univ.
Bremner, J. F., Consultant.
Brett, Ian, F.C.
Burnett, W. S., Canada.
Burns, L. V., Italy.
Burton, A. M.
Burton, E. S. V., F.C.

Caborn, J. M., Edinburgh Univ.
Cadman, W. A., F.C.
Cameron, J. D., F.C.
Cameron, R. D.
Campbell, John.
Carlisle, Alan, Aberdeen Univ.
Chapman, E. S. B., F.C.
Chapman, J. D., Nyasaland.
Chard, R., F.C.
Chrystall, J. G., F.C.
Chrystall, John, F.C.
Clay, A. J. M., S. Australia.
Collier, F. S., For. Advisor, Colonies.
Conder, E. M., F.C.
Cooper, D. J., F.C.
Coulson, T. W. G., F.C.
Crosland, J. V. S., F.C.
Crowther, R. E., F.C.

Daley, P. A., N. Nigeria.
Davies, E. J. M., F.C.
Davis, P. W., Aberdeen Univ.
Dawkins, H. C., Uganda.
Dent, T. V., F.C.
Dey, G. A., F.C.
Dickenson, M. E. S., F.C.
Dickson, Alex., Canada.
Dier, H. V. S., F.C.
Donald, F. J., F.C.
Donald, R. R., F.C.
Drummond, R. O., M. of A. (N.I.).
Dwight, Prof. T. W., Toronto Univ.
Dyson, W. G., I.F.S. (retired) Consultant.

Edwards, Johnston, Head Forester.
Edwards, M. V., F.C.

Edwardson, T. E., I.F.I.
Evans, W. D. D.

Fairbairn, Dr. W. A., Edinburgh Univ.
Farquhar, James, F.C.
Fergusson, J. L. F., F.C.
Fishwick, R. W.
Fletcher, J. R., F.C.
Francis, D. A.
French, W. F., F.C.

Garthwaite, P. F., F.C.
Gillespie, Ian, F.C.
Gilson, R. B., F.C.
Godwin, G. E., F.C.
Gore, N. H.
Gough, P. C., F.C.
Graham-Campbell, Dugald, F.C.
Grant, G. C., Aberdeen Univ.
Grayson, A. J., F.C.

Hamilton, A. P. F., I.F.S. (retired).
Hampson, J. R., F.C.
Hardcastle, E. J. B., F.C.
Hare, J. F., P.F.O.
Harris, E. H. M., F.C.
Harrison, J. C., F.C.
Hart, C. E., Chartered Land Agent and Surveyor.
Hewitt, R. M., F.C.
Hillman, C. H. R., F.C.
Holtam, B. W., F.C.
Horne, R. J. G., F.C.
Hughes, B. D., F.C.

Illingworth-Longbottom, Keith.
Innes, R. A., F.C.

Jackson, R. d'O. P., F.C.
Jackson, W. V., F.C.
Jenks, O. C.
Jennings, R. J., F.C.

Keen, J. E. A., F.C.
Keighley, G. D., F.C.
Kellie, John, F.C.
Kendall, R. H., F.C.
Kilpatrick, C. S., M. of A. (N.I.).
King, W. B.

Lancaster, P. C., Nigeria.
Langley, P. J., F.C.
La Touche, J. F. D.
Leadbeater, Illingworth, P.F.O.
Leefe, J. D., F.C.
Legard, P. H., F.C.
Lindsay, F. W., F.C.
Lindsay-Smith, W. A., F.C.
Lines, Roger, F.C.
Lloyd, A. H., I.F.I.
Lorimer, J. T., P.F.O.
Loveridge, Ralph, Head Forester.

Macalpine, R. I., India.
MacCormack, James, Head Forester.
Macdonald, Roderick, F.C.
McGarva, J. F., F.C.
MacGregor, J. J., Oxford Univ.
McIntyre, P. F., F.C.
MacIver, I. F., F.C.
Mackay, D., F.C.
Mackenzie, G. I., F.C.
McKune, Frederick, Head Forester.
McNamara, P. J., W. Australia.
McNeill, Ian, F.C.
Macpherson, Malcolm, F.C.
Martin, R. K., P.F.O.
Massey, J. E., F.C.
Matthews, J. D., F.C.
Maund, J. E., F.C.
Maxwell, H. A., F.C.
Miller, A. D. S., F.C.
Miller, R. G., Directorate of Colonial Surveys.
Mitchell, B. A., Selangor, F.M.S.
Mitchell, T. C., F.C.
Mithen, D. A., F.C.
Mooney, H. F., Lebanon.
Munro-Ferguson, A. B. L., of Novar.
Murray, J. S., F.C.

Newton, J. P., F.C.
Norris, J. C., Solicitor.

O'Dell, Prof. A. C., Aberdeen Univ.
Osmaston, F. C., I.F.I.
Osmaston, J. F., F.C.
Overell, P. A. W., F.C.
Owen, T. H., Univ. Coll. of N. Wales.

Payne, Robert, F.C.
Petrie, S. M., F.C.

Ramsay, Dr. D. M.
Richards, E. G., F.C.
Richardson, S. D., Aberdeen Univ.
Rix, A., F.C.
Roberts, K.
Robertson, D. Y. M., F.C.
Robertson, I. O., F.C.
Robertson, S. U., F.C.
Ross, C. Y., Head Forester.
Rowan, A. A.
Rowland, Langshaw, Director of Woodlands.

Sale, G. N., P.F.O.
Salter, I. J. W., Edinburgh Univ.
Seal, D. T.
Shaw, W. B. K.
Simpson, A. N., Head Forester.
Simpson, A. W., M. of A. (N.I.).
Skinner, J. R., F.C.
Spencer, A. J., F.C.
Spencer, J. A., F.C.
Stein, A. H., F.A.O., For. Mission to Chile.
Stern, R. C., F.C.
Stewart, G. G., F.C.
Stirling, James.
Stumbles, R. E., F.C.
Sutherland, J. W. R., Univ. Coll. of N. Wales.
Sutherland, W. B., F.C.
Sweet, J. M., I.F.S. (retired).

Taylor, G. J. N., F.C.
Thomas, K. P. A.
Tilney-Bassett, H. A. E., F.C.

Townsend, K. N. V., F.C.

Varty, I. W., F.C.
Voysey, J. C., F.C.

Wallace, D. H., F.C.
Walton, A. B., N. Borneo.
Waters, R. M., Tanganyika.
Watt, I. S., F.C.
West, D. H.
Weston, Fred, F.C.
White, John, F.C.
Williams, M. R. W., F.C.
Wilson, K. W., F.C.
Wilson, P. J. D., P.F.O.
Winchester, P. L., F.C.
Wood, R. F., F.C.
Wood, R. W., Consultant.
Woodburn, D. A., F.C.
Workman, J. H. B., Forestry Adviser.
Wylie, N. A., Canada.

Zehetmayr, J. W. L., F.C.

PROFESSIONAL MEMBERS

Archer, J. L., Forester.
Armstrong, H. O., Forester.

Banner, J. S., Head Forester.
Bartholomew, C. R., Forester.
Bayne, Andrew, Head Forester.
Beasley, G. F., Head Forester.
Betterton, S. J., F.C.
Brailli, M. J., Student.
Brandie, W. J., Woods Manager.
Broll, J. L., Forester.

Carruthers, M. F., Forester.
Chalmers, W. S., Forester.
Chisholm, M. R., Forester.
Christie, J. M., F.C.
Clark, David, Forester.
Clissold, J. W., Forester in Charge.
Cochrane, Andrew, Forester.
Corder, H. A., Nurseryman.
Cousins, D. A., F.C.
Craig, J. S., Forester.
Cutting, J. D., F.C.

Dalgleish, T. W., Consultant.
Dallas, W. G., Forestry Student.
Davidson, J. R., F.C.
Dowden, H. G. M., Foreman Forester.
Drysdale, Alex., F.C.
Dunn, J. F., Head Forester and Consultant.

Edmondson, J. T., Head Forester.
Ellis, W. H., Forester.
Evans, R. J., Forester in Charge.
Evans, W. R., F.C.

Featherstone, C., F.C.
Flemons, T. J., Forester.
Flynn, A. E., F.C.
Fraser, Elliott, Foreman Forester.

Goodwin, J. M.
Graham, Alex., F.C.
Grant, E. S., Consultant.
Gray, W. G., Head Forester.
Gutch, J. H. M., Forester.

Harkness, J. R., Forester.
Hart, R. B., Forester.
Heavener, C. H., F.C.
Hendry, J. B., Woods Manager.
Herbert, R. I., Forestry Student.
Hislop, J. J., F.C.
Hurst, R. T., Forestry Student.
Hutt, P. A., Head Forester.
Hyett, Samuel, Forester.
Hytch, F. A. L., Forestry Student.

Irvine, T. K., Head Forester.

Jamieson, R. A., F.C.
Jeffers, J. N. R., F.C.
Jones, E. B., Forester.
Joslin, A., Forestry Student.

Kimber, P. C., Forestry Student.
King, A. J., Forester.
Kirk, D. M., Forester.
Kirkland, C. P., Foreman Forester.

Locker, F. A., Forest Manager.

McEwen, John, Consultant.
MacGregor, Neil, Head Forester.
Macintyre, J. F., Forester.
Mackay, W. H., State Forester.
MacKenzie, A. M., F.C.
McMillan, G. H.
McNaught, D. J., F.C.
McNicol, F., Forester.
Macrae, A. D., Head Forester.
Marriner, E. W., Head Forester.
Melville, John, Forester.
Milnes, Mervyn, F.C.
Mould, A. G., Technical Assistant.
Mowat, John, Forester.
Mowat, William, Head Forester.
Muggleton, H. G., F.C.

Nimmo, Maurice, F.C.

Oetzmann, E. N.

Paley, James.
Parkin, K. F., M. of A. (N.I.).
Parkinson, Jack, Forester.

Parley, C. W., Forester.
Pashley, Frank, Forester in Charge.
Patterson, Burnett, Forester.
Priestley, F. J., Forester.

Roe, John, Head Forester.
Roe, W. T., F.C.
Ross, Duncan, Head Forester.
Rowland, John, Head Forester.

Scott, J. F., Forester.
Shaw, Robert, F.C.
Shepherd, W. R., Consultant.
Slater, John, Forester.
Small, J. R. M.
Spiers, D. R., Forester.
Stephenson, Francis, F.C.
Stewart, A. G., Forester.
Stone, P. L., Forestry Student.

Taylor, C. E., F.C.
Towns, K. W., Forester.
Tugwell, D. G., F.C.

Urquhart, George, Forester.
Usher, G. A., Head Forester.

Ward, M. H. P., Forester.
Ward, Walter, Head Forester.
Warren, Denis, Head Forester.
Watson, J. D., F.C.
Weatherell, John, F.C.
Westall, A. W., F.C.
Wilkinson, E. J. D., Forester.
Williams, Owen.
Wood, J. A., Forestry Student.

ORDINARY MEMBERS

Adams, Capt. E. W.

Bacon, Sir Edmund C., Bt.
Bannerman, J. M.
Bowser, Major D. C., of Argaty.
Brodie, Major D. J., of Lethen.
Brownlie, Alex., Timber Merchant.
Buccleuch, The Duke of.

Calder, Sir James C., of Ledlanet.
Campbell, Sir George, of Succoth.
Cawdor, The Earl.
Clark, N. G., Timber Merchant.
Clegg, J. C.
Clinton, The Lord.
Conservator of Forests, Tanganyika.
Corbett, The Hon. J. M.
Cotterell, Sir Richard C. G., Bt., of Garnons.

Dundee, The Earl of.

Edwards, J. K., Natal.
Elmhirst, L. K., of Dartington.
Evans, Major J. D. D., of Ffrwdgrech.

Forestry Commissioners.
Frost, Finn, Newfoundland.

Garside, G. H., Director of Parks.
Gilmour, Sir John E., Bt., of Montrave.
Gladstone, John, of Capenoch.

Hills, A. L. F., of Redleaf.
Hoare, H. P. R., of Stourhead.
Holbrow, W. G., Timber Merchant.
Hudson, R. H.

Institute and College of Forest Research, India.

Jacob, G. R., Timber Merchant.
Jedrosz, W. A.
Johns, C. G., Forest Ranger, Fiji.
Jörgensen, O. M., Denmark.

Kenworthy, Alan, Managing Director.
Kirkup, Austin, Timber Merchant.

Lewthwaite, Sir William A., Bt., Solicitor.
Longhurst, S. C., Timber Merchant.
Luttrell, G. F., of Dunster.

McCarthy, B. S., Estate Manager.
Macdonald Lockhart, S. F., of The Lee.
McGeorge, T. H., F.C.
McLinden, Derek, Nyasaland.
Macqueen, G. C. F., Timber Merchant.
Matthiessen, P. H., & Co. Ltd., Newcastle.
Meynell, R. W., of Berry Hall.
Ministry of Agriculture, N. Ireland.
Mitchell, Major Charles, of Pallinsburn.
Mitchinson, Miss I.
Moore, Barrington.
Moulton, H. W., J.P., Norfolk.

Newport, The Viscount.
Nicholson, J. H. D., Forestry Student.

Owen, Major A. L. O.

Palmer, G. E. H.
Paterson, R. C., Timber Merchant.
Penfold, Lt. Col. R. J. L., Land Agent.
Proby, Major Sir Richard, Bt., of Elton Hall.

Radnor, The Earl of.
Rainford, W. A., N. Rhodesia.
Riddoch, W. J., Timber Merchant.

Sadd, H. N., Timber Merchant.
Seymour, Major W. N., Estate Agent.
Shackleton, J. F., Nurseryman.
Shepherd, W. J.
Smith, H. J. F., National Trust.
Smith, J. T., Timber Merchant.
Soffe, A. C., S. Rhodesia.
Stirling, Major John, of Fairburn.
Stirling, Col. W. J., of Keir.
Strang Steel, Major F. W., of Philiphaugh.
Strang Steel, Sir Samuel, Bt., of Philiphaugh.

Tallents, T. W., Land Agent.
Trevelyan, J. T., J.P., of Longwitton Hall.
Tritton, P. A., Woodland Owner.

Vane, W. M. F.

Warde-Aldam, Col. W. St. A., of Hooton Pagnell.
White, R. J. B., Land Agent.
Williams-Ellis, R. C., of Glasfryn.
Wills, Capt. W. D. M., of Barley Wood.
Wilson, R. F., Timber Merchant.
Wolryche-Whitmore, Capt. G. C., of Dudmaston Hall.
Workman, F. E.

Yerburgh, J. M. A.

The list has been compiled from the information available in the Society's records. Where no descriptive initials are given, this is due to lack of information, and members affected are asked to send the appropriate details to the Secretary now. Members are asked to notify any changes of address, description, &c., as soon as they occur, so that the records may be kept up to date.

SOCIETY'S AND OTHER NEWS

HONOURS

We offer our congratulations to Mr. A. H. Gosling C.B., Director-General Forestry Commission, a past President of this Society and a member of the Council, on his being made Knight Commander of the Most Excellent Order of the British Empire and to Mr. R. B. Gardner, Secretary to the Royal Forestry Society of England and Wales who is made an officer of the same Order. Both names appear in H.M. The Queen's Birthday Honours List.

MISS MARY SUTHERLAND

We record with great regret the loss of the only woman Fellow of this Society. Miss Sutherland died recently in New Zealand where she had done valuable work in forestry for many years. She graduated in forestry at Bangor and was, we believe, the first woman to do so anywhere.

EXCURSIONS

An account of the successful Lake District excursion will appear in the next number, together with the President's address to the Society. It is intended to hold the 1956 meeting in Scotland at Pitlochry in September when the theme for the meeting will be 'Management', and it is hoped to allot rather more time than usual for its discussion.

OXFORD UNIVERSITY SCHOOL OF FORESTRY

On 1 October 1955, the Oxford School of Forestry will be celebrating the Jubilee of its opening in 1905. The programme will include a Jubilee Address at the Imperial Forestry Institute, a luncheon party in St. John's College, and a visit to Bagley Wood, where commemorative trees will be planted. Invitation is extended to all past and present students of the School and also to all who have attended courses at the Institute which, since its foundation in 1924, has always shared staff and buildings with the School. It is hoped that everyone who is able to do so will join in the celebration personally.

It has been suggested that there could be no better way of marking the occasion than by instituting a prize for the most meritorious student completing his undergraduate study during the year. At present the School lacks such an annual prize. Subscriptions are being invited and it is hoped to collect £500.

[*continued from inside front cover*

The membership is divided into four classes, the respective qualifications being as outlined below:

FELLOWS: Subjects of the British Crown fulfilling all four of the following requirements: (1) A degree or diploma in forestry, &c. (2) Five years of practical experience in forestry, &c. (3) Having been a Professional Associate for 5 years. (4) Having had a thesis or published article approved by the Council. Annual subscription £1. 11*s.* 6*d.* (Twenty-five guineas for life.)

PROFESSIONAL ASSOCIATES: Subjects of the British Crown fulfilling any one of the following requirements: (1) A degree or diploma in forestry, &c. (2) Having made important contributions to forestry, &c. (3) Considered by the Council to occupy a post normally held by a holder of a university degree in forestry. Annual subscription £1. 1*s.* 0*d.*

PROFESSIONAL MEMBERS: Subjects of the British Crown resident in Great Britain, engaged whole time in forestry but not eligible for above classes. Annual subscription 10*s.* 6*d.*

ORDINARY MEMBERS: Persons or corporate bodies not eligible for any of above classes. Annual subscription £1. 1*s.* 0*d.*

Fuller details of qualifications may be obtained from the Secretary.

Only Fellows are eligible for the higher offices and for most seats on the Council, but one Councillor may be a Professional Associate and one a Professional Member. Office bearers and Councillors are selected by written nomination and postal ballot. Fellows and Professional Associates have full voting rights, but Professional Members have only limited voting rights.

LIST OF OFFICE BEARERS 1955–6 AND COUNCILLORS 1955–7

President: W. E. HILEY. O.B.E., M.A., Dartington Woodlands Ltd., Totnes, Devon.

Vice-President: A. P. LONG, C.B.E., B.A., Chatley, Martins End Lane, Great Missenden, Bucks.

Editor: R. W. V. PALMER, B.A., Bannerleigh, Leigh Woods, Bristol.

Business Editor: H. L. EDLIN, B.SC., Forestry Commission, 25 Savile Row, London, W. 1. Tel. REGENT 0221.

Secretary and Treasurer: R. A. GALLOWAY, O.B.E., M.C., B.SC., Solicitor, 7 Albyn Place, Edinburgh, 2. Tel. CAL. 7402.

Auditor: D. L. FERGUSON, 11 Carlton Terrace, Edinburgh, 7.

Councillors: while immediate past president, SIR ARTHUR GOSLING; *retire in* 1956 *but eligible for re-election,* SIR HENRY BERESFORD-PEIRSE, A. H. H. ROSS, PROF. H. G. CHAMPION, M. V. LAURIE, and JOHN MAXWELL MACDONALD; *retire in* 1957 *but eligible for re-election,* G. W. BACKHOUSE, J. E. GARFITT, R. H. HIDE, W. M. MCNEILL, and PROF. E. C. MOBBS.

CONTENTS

Notes on forestry in Sicily (*with Plates IV and V*). By JAMES MACDONALD 81

Fourth World Forestry Congress 94

The occurrence of podzols under deciduous woodland in the New Forest. By G. W. DIMBLEBY and J. M. GILL 95

The influence of weather on the frequency of beech mast years in England. By J. D. MATTHEWS 107

Thoughts on yield tables. By F. C. OSMASTON 117

The relation between dry weight increase and linear measures of growth in young conifers. By A. J. RUTTER 125

The effect of rainfall on the late wood of Scots pine and other conifers in East Anglia (*with Plate VI*). By E. H. M. HARRIS 136

A comparison of light in different woodlands. J. D. OVINGTON and H. A. I. MADGWICK 141

The influence of heather mulching on the growth and nutrient status of Lawson cypress. By L. LEYTON 147

REVIEWS

Thinning problems and practices in Denmark (CARL MAR: MÖLLER, JÖRGEN ABELL, THÖGER JAGD, and FLEMMING JUNCKER). By F. C. HUMMEL . 152

American Forest Management (KENNETH P. DAVIS). By W. M. MCNEILL . 153

Forest Mensuration (H. ARTHUR MEYER). By T. E. EDWARDSON . . . 155

Forests of France (J. L. REED). By N. V. BRASNETT 156

Full-Tree Logging (A. KOROLEFF). By E. G. RICHARDS 157

The Queen Elizabeth Forest Park Guide (Forestry Commission). By C. W. SCOTT 158

LIST OF MEMBERS

List of Members of the Society as at 23 March 1955 159

SOCIETY'S AND OTHER NEWS

Honours — Miss Mary Sutherland — Excursions — Oxford University School of Forestry Jubilee 164

Printed in Great Britain at the University Press, Oxford, by Charles Batey, Printer to the University